EFFECT OF TRANSPLANTING DATE ON THE GROWTH AND YIELD OF AMAN RICE IN POLDER ECOSYSTEM OF THE SOUTH-WESTERN COASTAL ZONE OF BANGLADESH

SUJAT AHMED

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA-1207

DECEMBER, 2017

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BY

SUJAT AHMED
REGISTRATION NO. 16-07568

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JULY- DECEMBER, 2017

APPROVED BY:

Prof. Dr. Md. Abdullahil Baque **Supervisor**	**Dr. S.V. Krishna Jagadish** **Co-Supervisor**

Prof. Dr. Md. Shahidul Islam
Chairman
Examination Committee

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF TRANSPLANTING DATE ON THE GROWTH AND YIELD OF AMAN RICE IN POLDER ECOSYSTEM OF THE SOUTH-WESTERN COASTAL ZONE OF BANGLADESH"*** *submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***AGRONOMY****, embodies the result of a piece of bona fide research work carried out by* ***SUJAT AHMED*** *, Registration No.* ***16-07568*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has duly acknowledged.

Dated:
Dhaka, Bangladesh

Prof. Dr. Md. Abdullahil Baque
Supervisor
Department of Agronomy
Sher-e-Bangla Agricultural University,
Dhaka-1207

ACKNOWLEDGEMENT

I start with the name of Almighty Allah, which is most Beneficent and Merciful. The author would like to express his deepest sense of gratitude, endless praises and thanks to the almighty Allah for dealing his to get this far and for making all these possible, the Cherisher and Sustainer of the world. His kind blessings have enabled him to complete the paper.

The author wish to express his heartfelt gratitude and indebtedness to Dr. Md. Abdullahil Baque, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, for his constant supervision, valuable suggestion, scholastic guidance, continuous inspiration, constructive comments and immense help for writing this manuscript from its embryonic stage.

The author expresses his sincere appreciation, respect and immense indebtedness to respected co-supervisor Dr. S.V. Krishna Jagadish , Associate Professor, Department of Agronomy, Kansas State University, Manhattan, Kansas 66506, United States of America for cordial suggestions, constructive criticisms and valuable advice to complete the thesis.

The author would like to express his deepest respect and boundless gratitude to Dr. Manoranjan Mondal, IRRI, Bangladesh and Dr. Sudhir Yadav, Senior Scientist, Sustainable Impact Platform, IRRI, Philippines for support, encouragement, cordial suggestions throughout the research work. The author would like to expresses special thanks to International Rice Research Institute (IRRI) for technical guidance and support to complete this study.

This MS research study is made possible by the support of the American People provided to the Feed the Future Innovation Lab for Sustainable Intensification through the United States Agency for International Development (USAID). The contents are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government. Program activities are funded by the United States Agency for International Development (USAID) under Cooperative Agreement No. AID-OAA-L-14- 00006.

The author would like to express his deepest respect to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207 for the valuable teaching, co-operation and inspirations throughout the course of this study and research work. The author wish to express his cordial thanks to Sustainable Intensification Innovation Lab (SIIL) team of the research conducting area Batiaghata, Khulna for their active help during the experimental period. The author also sincerely express his heartfelt gratitude to the members of the advisory committee for their advices.

Lastly the author gratefully acknowledge to his beloved parents and also to his sisters, other relatives and well-wishers for the countless blessings, spiritual support and sacrifice throughout his academic life.

The author

ABSTRACT

A field experiment was conducted on the farmers' fields in polder 30, Batiaghata, Khulna during July 2017 to January 2018 in order to study the influence of different transplanting dates on the performances of aman rice under tidal ecosystem prevailing in the polders of the south-western coastal zone of Bangladesh. The experiment consisted of two level of treatments viz. variety and transplanting dates. The experiment was comprised with two rice varieties viz. BRRI dhan52 and Kumragor (local T. aman rice) and seven transplanting dates viz. 1 July, 10 July, 20 July, 30 July, 10 August, 20 August, 30 August. The experiment was laid out in Randomized Complete Block Design (RCBD) with five dispersed replications. Results indicate that variety and date of transplanting exerted significant influence on the crop characters of aman rice. BRRI dhan52 produced the highest grain yield (3.51 t ha^{-1}), straw yield (3.72 t ha^{-1}), biological yield (7.24 t ha^{-1}), and harvest index (48.30%). The lowest grain yield (2.71 t ha^{-1}), straw yield (4.40 t ha^{-1}) and biological yield (6.57 t ha^{-1}) and harvest index (32.88%) were obtained from Kumragor. Kumragor took longest duration 152 days to mature while BRRI dhan52 took 133 days to mature. Plant height (140.12 cm), number of total tillers $m-^{2}$ (240), number of grains $panicle^{-1}$ (132.19), grain yield (3.63 t ha^{-1}), straw yield (4.60 t ha^{-1}), biological yield (8.27 t ha^{-1}) and harvest index (44.01%) were highest with 10 August transplanting and decreased gradually after mid-August transplanting but drastically declined with 30 August transplanting. Drastic decrease of yield was showed on both of the transplanting date 1 July and 30 August. The present study indicates early August to be the most suitable transplanting date for aman rice in polder ecosystem of coastal zone.

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LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
AIS	=	Agricultural Information System
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centimeter
cv.	=	Cultivar
CGR	=	Crop growth rate
CAR	=	Conventional application rate
DAT	=	Days after transplanting
^{0}C	=	Degree Centigrade
Df	=	Degree of freedom
DAP	=	Diammonium phosphate
DMA	=	Dry matter accumulation
Ec	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
FYM	=	Farmyard manure
G	=	Gram
GDP	=	Gross domestic product
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	Hour
IRRI	=	International Rice Research Institute
Kg	=	Kilogram
LV	=	Local variety
LSD	=	Least significant differences
MV	=	Modern variety
MoP	=	Murate of potash
Mm	=	Millimeter

M	=	Meter
N	=	Nitrogen
NS	=	Non-significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
SRDI	=	Soil Resource and Development Institute
t ha^{-1}	=	Tons per hectare
TSP	=	Triple super phosphate

CHATEPR 1

INTRODUCTION

More than one million hectares of land in the coastal zone of Bangladesh are contained within low-lying tracts of land enclosed by embankments and surrounded by tidal rivers known as polders. Constructed during the 1960s and 1970s, the polders (139 in total) were designed to control tidal flooding and, thereby, increase agricultural production in coastal areas. (FAO, 2012). The coastal region of southern Bangladesh is home to some of the world's poorest, most food insecure, malnourished and socioeconomically challenged people. While farm productivity and profitability have greatly increased through intensification and diversification of agricultural systems over the past 30 years to the rest of Bangladesh, the polders are left behind with traditional practices (Yadav *et al., 2016*). Resources in the coastal zone of Bangladesh are underutilized, despite many opportunities for increasing its contribution to the national food basket. Limitations and vulnerabilities of the coastal region are mainly due to its geographical location, and are further aggravated by climate change. The biophysical environment in the coastal zone of Bangladesh is very diverse, and it varies greatly over short distances, particularly in the incidence and severity of water stagnation and salinity. (Abdullah *et al., 2016)* Polder zones are vulnerable to the effects of climate change driven rising sea level, and flooding. The hydrology of the coastal zone is quite different from other parts of Bangladesh. It is governed by the lunar tidal phenomenon and man-made sluice gates in the polder ecosystem. In the coastal zone, high and low tides occur twice daily. The low farm productivity stems from water management issues. The nature of the polders requires water to be managed with sluices. There is both temporal and spatial dynamics of salinity. Water remains almost fresh in the eastern part of the coastal zone, and salinity increases as we move toward the southwestern part of the coastal zone. Salinity levels are also high in the dry season compared to the wet season. (Yadav *et al., 2016*). The tidal wetlands covering one-third of the total cultivated area of Bangladesh face many constraints, related to environment and cultural practices. The major environmental problem for crop production in the non-saline tidal wetland situation is twice daily inundation of land over a period of 4-8 months (April- November) of the year. Crop production in Bangladesh mainlydepends on nature. Flash flood or late flood often damage transplanted aman rice partially or completely. Fifty percent of total transplanted aman rice area is planted late in Bangladesh due to unfavorable climate, non-availability of inputs at proper time and practice of low and upland cropping patterns (BRRI, 2007). About 30-40% area of aman rice is planted beyond optimum period due to delayed harvest of aus rice (BRRI 2005).

Rice (*Oryza sativa* L.) belongs to the cereal crops under Graminae family. Rice is the most important food crop around the world and the staple food for approximately more than two billion people in the Asia (Hien *et al.,* 2006). Rice is also the main food crop of Bangladesh and it covers about 80% of the total cropped area of the country (AIS, 2013). Rice provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intake of an average per person in the country. About 75% of the total cropped area and over 80% of the total irrigated area is covered by rice (BBS, 2008). Thus, rice plays a vital role in the livelihood of people of Bangladesh. Total rice production in Bangladesh was about 10.97 million tons in the year 1971 when the country's population was only about 70.88 millions. At present the country produces about 57 million tons to feed 153 million people. Population growth rate in Bangladesh is two million people per year and the population will reach 233.2 million by 2050. If it follows the current trend, Bangladesh will require more than 55.0 million tons of rice per year to feed its people by the year 2050 (IFPRI, 2013). The nation is still adding about 2.3 million every year to its total 150 million people (Momin and Husain, 2009). During this time total rice area will also shrink to 10.68 million hectares, hence rice (milled) yield needs to be increased from the present 2.44 to 3.74 t ha^{-1} (BRKB, 2007). Rice is grown in Bangladesh in three distinct rice growing seasons namely Aus, Aman and Boro. Among these seasons, aman rice covers the 5.66 million hectares with a production of 13.3 million tons (BBS, 2018). Rice yield in Bangladesh is less due to use of high yielding varieties (HYV) in a limited extent and inappropriate agronomic management practices. In the year 2006-2007, the total area and production of rice in Bangladesh was about 10.53 million hectares and 27.32 million tons, respectively (BBS, 2007). At present, production of rice in Bangladesh is about 53 million tons (BBS,2017) Productivity of aman rice is particularly low in most of the coastal areas because of excessive flooding and less adoption of suitable high yielding varieties (HYV) of rice. Besides this in the polder ecosystem of the coastal zone of Bangladesh most of the farmers cultivate local traditional aman rice varieties giving lower yields as compared to other parts of the country. More than 30% of the cultivable land in Bangladesh is in the coastal area, about 1.0 million ha of which is severely affected by varying degrees of flooding/submergence during the wet season each year. In general, more than 50% of the polder area remains fallow during the dry season, mainly due to high soil salinity and lack of fresh water. Most farmers in the polders cultivate a single low-yielding rice crop in a year, which is sometimes followed by low-yielding dry-season crops. Due to stagnant flooding, most farmers of the coastal zone of Bangladesh grow a single rice crop (aman) during the rainy season using tall, photoperiod-insensitive, local landraces, which can survive under stagnant flooding, but have low yield (2.0-3 t/ha) and mature late (growth duration: 155-170 d). The aman crop is often followed by a late sown, low input and low yielding Rabi crop (0.5-1.0 t/ha), whichencounters severe damage or crop failure in about 40% of the years due to the pre-monsoon rains and cyclones in May. (Yadav *et al., 2017*) In the last five years (2011-2016), dry-season crops in the polders were severely damaged by rainfall and cyclonic storms coinciding with crop maturity during May (AIS, 2017). As a consequence, farmers are reluctant to cultivate in dry season and most of farmers (40-50%) of the coastal zone leave their land as fallow for 3 to 7 months every year. Historically, farmers in the polder region drain their field in November- December and harvest their crop of traditional rice in December-January. The field remains too wet for a month or so, and farmers generally cannot grow dry-season crops until mid-February. Most of the time, the dry season crops are destroyed by pre-monsoon rains prior to maturity. In the dry season, more than 90 percent of the farmland in the polders is fallow. In the rainy season, rice crops frequently become submerged in water and die before they can be harvested. Early planting of the dry-season crop and managing water properly inwet-season rice are both components of rice management. As of now, these are not well coordinated to allow uniform planting and harvesting. These problems could be solved by finding crops better suited to the polders' unique environmental conditions. However, there is huge scope for increasing cropping system productivity in the coastal zone. Cropping diversity increases the resilience of the farming system and greatly reduces the risk of damage or complete loss of crops from pre-monsoon rains and cyclones.

In polder ecosystems specification of transplanting dates of aman rice is an important factor that influences the growth, development, yield and yield components of transplanted aman rice significantly. The optimum date of transplanting would be helpful to cope with different tidal phenomena and manage water levels. Considering the situation priority should be given to bring more acreage under HYV (High Yielding Variety) of aman rice cultivation rather than the cultivation of local varieties and specify the most effective suitable date transplanting at early aman to ensure enough time for rabi cropping. To facilitate rabi crop production before late boro sowing, optimum date of transplanting for high yielding aman rice variety (ies) is very important. The present studies were planned to investigate the response of different aman rice varieties to different dates of transplanting. My research focus was aimed to increase farm income and nutrition security by intensifying polder farming systems through implementation of sustainable and economically viable rice cultivation practices with the following objectives:

- ✓ To find out the most suitable transplanting date of aman rice in polder ecosystem based on local hydrological condition and water management system,
- ✓ To assess and compare the performances of the High Yielding Variety (HYV) of rice and Local Rice landraces with respect to particular polder ecosystem.
- ✓ To ensure sufficient time for rabi crops and avoid the loss due to pre-monsoon natural calamities by advancing transplanting date of amanrice.

CHATEPR 2
REVIEW OF LITERATURE

Rice being an important food crop of the world has been studied by number of research workers for different inputs and agro-techniques in various parts of the world. It is always desirable to study a brief resume of work done before undertaking any scientific investigation on those lines, because this gives scope to formulate new objectives and strategies in experimentation. Rice is he major cereal crop in Bangladesh. Cultivars, production environment and agronomic management practices are closely related factors determining the efficiency of crop production. The present field trial was designed to find out the effect of transplanting dates on performance of different Aman rice varieties in polder ecosystem of southwestern coastal zone Bangladesh. A number of research studies have so far been conducted on transplanting dates of rice at different rice growing regions of the world. In this chapter an attempt has been made to critically review the pertinent research works carried out related to the context stated above. Cultivation of short duration aman rice in south-western part of Bangladesh where soil remain moist before harvest as the soil is clay loam to clay textured may create opportunity to reduce the cost of land preparation, water requirement and ultimately reducing cost of production for mustard relay cropping and increase cropping intensity of T. aman - mustard - DDSR boro rice system (Khan et al., 2006). Cultivation of short duration T. aman rice can also create opportunity to facilitate legume pulses and green manuring crops before late boro sowing which can contribute significantly to achieve the twin objectives of increasing productivity and improving the sustainability of T. aman-pulses-boro rice cropping system (Quayum et al., 2012).

Choosing optimum date of transplanting occupies an important part of high production package. Transplanting dates have been shown to provide differential growth conditions such as temperature, precipitation and growth periods. Different author(s) reported the benefits of choosing optimum planting dates in rice and in most of the cases, neither too early nor too late transplanting proved to give better yield response by offering prolonged or shorter growth period while eliminating chances of escaping heat stress during reproductive growth (Safdar et al., 2008 and Hossain, 2007). Temperature is the key factor to be affected by transplanting dates in rice. Different authors used different planting dates to check contrasting temperature regimes in various rice varieties (Laborte et al., 2012; Rahman et al., 2003 and Rahman et al., 2007). They concluded that late transplanting dates coincided with reproductive phase temperature stress while early planting helps to escape from temperature stress. Therefore, late planting is considered as the factor to reduce the growth and yield. But early planting is not possible under all scenarios, due to existing cropping pattern, climate change and socio-economic condition. A compromise is therefore, needed between sacrificing grain yield by adjusting transplanting date (Basal et al., 2009 and Rauf et al., 2007).

Cultivar is one of the most important factors which contribute much in producing yield and yield component of rice. Yield of the cultivar is directly related to environment in which it grows. Higher yield could be achieved from the suitable cultivar if appropriate method of planting is used (Akhter et al., 2007).

To facilitate rabi crop production before late boro sowing optimum date of transplanting for best aman rice variety (ies) is very important. For this reason, it is important to investigate the response of different aman rice varieties to date of transplanting.

2.1 Response of date of transplanting on the performances of aman rice

The factors that affect plant growth can be classified as genetic and environmental. Among the external conditions temperature, moisture supply, radiant energy, composition of the atmosphere, soil aeration and soil structure, soil reaction, biotic factors and supply of mineral nutrients substances are most important for crop growth and development. Each can be a limiting factor in plant growth. Rice plants require a particular temperature for its phenological stages such as panicle initiation, flowering, panicle exertion from flag leaf sheath and maturity and these are highly influenced by the planting dates. Delay in planting generally results in yield reduction which cannot be compensated by any other means. Hybrids have relatively higher degree of thermo sensitivity during flowering and grain filling stages as compared to high yielding varieties. Too high or too low temperature may cause damage during flowering and prevent pollen shedding leading to increased infertility and production of chaffy grains. In order to ensure normal flowering, fertilization and avoid damage due to high or low temperature, it is necessary for timely sowing and transplanting of rice. Timely transplanting of rice results in earlier harvest and allows timely planting

of the next rabi crops. Many factors are attributed to obtain the higher biomass production and among them selection of rice hybrid plays a vital role in augmenting rice grain yield. Transplanting younger seedlings is an important aspect. Tillering habit of rice plant is greatly influenced by the age of seedling at transplanting. The young seedling recorded better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the plant growth and development, ultimately resulted in increased grain yield. Rice yields may reduce by planting too early and also by planting too late i n the growing season. If rice is planted extremely early, it could run into: 1) slow emergence, poor growth, lack of seedling vigor due to unfavorable weather, 2) increased seedling disease damage, such as water mold, 3) increased bird damage, (Baloch et al., 2006). If rice i s planted too late: 1) yield potential decreases, 2) panicle blight problems associated with temperature stress during pollination and grain fill occurs,
3) increased potential for disease and insect problems, 4) decrease in grain quality,
5) problems in ratoon crop timing (Habibullah et al., 2007).

22 Effect Transplanting Date on Growth Parameters

2.2.1. Plant height

Naher et al. (1999) observed in a year round rice transplanting experiment in Bangladesh, that the transplanting dates showed significant differences in plant height. May to August planting showed taller plants whereas October and November planting produced shorter plant.

A field experiment was conducted by Islam et al. (2008) at Mymensingh, Bangladesh to find out the effect of transplanting dates on growth parameters of aromatic rice (cv. ‘Kalizira’). They found that the transplanting on 10 August exhibited maximum plant height (137 and 135 cm, respectively) and number of effective tillers hill^{-1} (12.2 and 9.40, respectively) over 22 August and 04 September transplanting during both the years.

Yaduvanshi (2007) while evaluating the performance of rice varieties in relation to planting dates in lowland ecosystem of Bihar on clay loam soil found that significantly higher plant height when the crop was transplanted on June 18 and July 2, which were on par but had significantly higher plant height when compared to delayed planting of crop on July 16 and July 30.

Dhiman et al. (1995) observed that higher plant height and dry matter accumulation per plant in earlier planting on 15 July than in delayed planting on 25 July and 5 August.

Ghosh and Sharma (2000) reported that out of four dates of planting tested (May 10, May 20, May 30 and June 10planting), May 20 planting recorded higher plant height and numbers of tillers m^{-2} in comparison to May 10, May 30 and June 10 at Cuttack, Orissa on loamy soils.

2.2.2 Number of tillers hill^{-1}

A field experiment was conducted by Islam et al. (2008) at Mymensingh, Bangladesh to find out the effect of transplanting dates on growth parameters of aromatic rice (cv. 'Kalizira'). They found that transplanting on 10 August exhibited maximum plant height (137 and 135 cm, respectively) and number of effective tillers hill^{-1} (12.2 and 9.40, respectively) over 22 August and 04 September transplanting during both the years.

Pandey et al. (2001) noted that rice hybrid 'PA 6201' gave significantly higher productive tillers hill-1and dry matter accumulation plant-1 from the crop transplanted on 20 July and 4 August than that the crop transplanted on 20 August.

Nayak et al. (2003) conducted a field experiment on hybrid rice 'PA 6201' under climatic conditions of Bhubaneswar, Orissa on loamy sand soils, reported that early planting of 16 July exhibited the maximum total and effective tillers per hill, LAI and dry matter accumulation than that planting on 31 July and 16 August. One month delay in planting from 16 July reduced total tillernumber.

Experiment conducted by Khakwani et al. (2005) at DeraIsmile Khan, Pakistan with 6 dates of transplanting ie. 1st May, 15th May, 1st June, 15th June, 1st July and 15th July found that plant height and tillers hill^{-1}were affected significantly with different dates of transplanting and maximum plant height and tillers were recorded with 1st and 15th June of transplanting.

2.2.3. Dry Matter Production

Dhiman et al. (1995) observed that higher plant height and dry matter accumulation per plant in earlier planting on 15 July than in delayed planting on 25 July and 5 August.

Singh et al. (1997) conducted a field experiment at Kanpur and found that plant height, total tillers and dry matter accumulation of the crop transplanted on 5 July was more than that of the crop transplanted on 20 July and 4 August.

Pandey et al. (2001) noted that rice hybrid ‘PA 6201’ gave significantly higher productive tillers hill^{-1} and dry matter accumulation plant^{-1} with the crop transplanted on 20 July and 4 August than the crop transplanted on 20 August.

Kerketta et al. (2010) revealed that sowing on 11th July with 60:50 kg P: K has showed promising effect on growth and yield attributing characters. Moisture pattern also indicated that with the continuous availability of moisture around the season in early sowing i.e. 11th July sowing promoted root length, volume and dry weight in the direct seeded rained upland rice which was reflected through highest grain yield.

2.2.4 Days to Flowering and Maturity

BRRI (2005) conducted an experiment at the BRRI farm, Gazipur in the T.Aman season. The lines BR6592-4-6-5, BR6592-4-6-4 and IR70175-54-1-1-2-3-HR2 were tested and compared with BR11. And BRRI dhan32. Thirty-day old seedlings were transplanted during 15 July to 1 October at 15 days intervals. The promising lines BR6592-4-6-5, BR6592-4-6-4 gave more than 3.92 t/ha yield up to 15 September planting. Although grain yield of these two promising were greater than the check varieties irrespective of planting dates, they required about 7 days more for maturing compared to BRRI dhan32. Moreover, grain yield drastically reduced during 1 October planting which was related with water stress in the flowering stage. Growth duration of the tested lines varied from 131-137 days which was closer to BR11 and BRRI dhan32.

BRRI (1994) reported that the grain yield increased up to August transplanting and declined thereafter and panicles did not emerge when planted on September 15.

Haider et al. (2004) conducted a field experiment in Bangladesh on rice cultivars Nizersail, BR11 and BR22 to determine the effect of planting date (1 and 15 August; 1, 15 and 22 September, and 1 and 7 October) on phenological development, and to determine the degree of cultivar sensitivity to air temperature. Panicle initiation (PI) of BR11 was earlier than Nizersail and BR22 in early planting. In late planting, panicle initiation (PI) of BR22 was earlier than BR11 and Nizersail. The development of panicle initiation (PI) stage among the cultivars differed only by one day. Nizersail completed heading between 31 October and 9 December when transplanted during 1

August to 1 October. BR11 completed heading between 24 October and 18 November when transplanted during 1 August to 1 September. BR11 completed heading by 2 November to 20 December when transplanted between 1 August to 7 October. Nizersail, BR11 and BR22 matured during 26 November to 28 January, 21 November – 28 January and 1 December- 19 January, respectively. The flowering duration of Nizersail, BR11 and BR22 increased by 2-14, 3 and 3-20 days respectively, due to lower temperature and solar radiation.

2.3 Effect of Transplanting Date on Yield Contributing Characters

2.3.1. No. of productive Tillers m^{-2}

Mumin (2002) studied the influence of planting times on the yield and yield components of three aman rice varieties. Planting time exerted significant influence on most of the crop characters. Crop transplanted on 1 August produced maximum number of productive tillers m^{-2} compared to other planting times. The highest grain (4.16 tha^{-1}) and straw (5.09 t ha^{-1}) yields were observed from July transplanting.

Marambe (2005) observed that the tiller number varied from 14-18 per plant with 6-9 panicles $plant^{-1}$. There were more unproductive tillers on weedy rice plants than on the cultivated variety. BRRI (2012) reported that number of productive tillers by modern varieties ranged from 15-25, which significantly differs in varieties. It was also observed that total number of tillers and number of grains $panicle^{-1}$ differed significantly among the varieties.

2.3.2. No. of non-productive Tillers m^{-2}

Pandey et al (2001) stated that July 21 and August 5 gave the highest number of productive $tiller^{-1}$ and grain yield of hybrid rice. The number of tillers increased up to 60 days after transplanting (DAT). and declined thereafter while the weight of tillers and dry weight accumulation continued to increase till 90 DAT. The correlation coefficient indicated that the number of tillers and dry matter accumulation at 30 and 90 days after transplanting (DAT) were the most important parameters affecting grain yield.

Ali et al. (1999) recorded maximum number of productive total tillers (382 per m^2) when the crop was transplanted on 15 July, which decreased significantly with delayed planting on 30 July and 14 August.

Hari et a.(2000) found on 4 rice cultivars that the transplanting seedlings on 25 June produced the highest number of productive tillers m^{-2} , panicle weight and grain yield than June 15, or July 15.

2.3.3. Panicle length

Chopra and Nisha (2004) conducted a field experiment during the rainy season 2000 and 2001 in Karual, Haryana, India to assess the effect of transplanting date (30 June, 7,14, 21 and 28 July and 4 August) on seed yield and quality of 'Pusa Basmati 1' scented rice. Transplanting on 30 June resulted in significantly higher panicle length (30.4 cm), panicle weight (3.83 g), 100 seed weight (21.12 g) and seed yield (56.53) than that of 21 and 28 July and 4 August, but was statistically at par with 7 and 14 July planting. Seed quality in terms of germination was higher than the minimum seed standard (80%) up to 21 July. However, germination was below the minimum standard on 28 July and 4 August. Moreover, superior seed quality in relation to electrical conductivity (0.23mS cm^{-1} g^{-1}) was observed on June 30 transplanting compared to later on 21 July (18%) compared with 30 June transplanting.

Uddin and Azam (2001) reported the effect of planting dates on Basmati rice varieties. Dates of transplanting were July 25, August 11, September 5, and September 25 in 2000. The characters like plant height, number of effective tillers and panicle weight and length showed significant positive correlations with early transplanting dates.

2.3.4. Spikelet Sterility

Singh et al. (2005) conducted a field experiment during Kharif 1995 and 1996 to study yield and spikelet sterility of rice in temperate Kashmir as influenced by transplanting dates and nutrient management. Spikelet sterility was higher (low grain yield) in rice transplanted on 30 June in compared with that on 15 June due to reduced growth phases and low temperature during reproductive phase.

2.3.5. 1000- Grain Weight

Neerja and Sharma (2002) conducted an experiment on non-aromatic (cvs.IR8, PR113, PR103, PR106) and aromatic (cvs. Basmati 370, Basmati 385, Basmati 386, Pusa Basmati No, 1) rice and found that the highest 1000 kernel weight of brown rice was recorded for PE113. Hossain (2007) reported that the weight of thousand grains varied from 22.1 g to 27.3 g among BRRI dhan33, BRRI dhan39 and BRRI dhan49.

Singh et al. (2000) found that Neamat, Shel (7325 line) and Fajar (7328 line) and their transplanting dates with 10-day intervals from 13 March to 1 June 1998. Traits suchas grain yield, biomass and harvest index, tiller number, grain numberpanicle^{-1}. Panicle fertilized percentage and 1000 seed weight at different transplanting dates were evaluated. The delay in transplanting date decreased tiller number, panicle fertilization percentage, grain number panicle^{-1}, the grain yield and the harvest index, but there were no significant differences in 1000-seed weight and biomass for different transplanting dates.**2.3.6. Grain Yield**

Kumar et al. (2005) observed the effect of varietal differences of modern transplanted aman rice. Among different varieties (viz. Jaya, Rasi, IR20, and Margala) IR20 yielded 7.9 t ha^{-1} and Rasi 6.2 t ha^{-1}. The highest yield was in Jaya 8.4 t ha^{-1}. Diaz et al. (2001) noted wide variation in panicle length, grains per panicle and panicle weight and secondary branches panicle^{-1} among the varieties which are responsible for variation in grain yield. Shriname and Muley (2003) studied the heritability and correlation studies of different biotic and morphological plant characters with grain yield in rice hybrid and cultivars and observed that grain yield exhibited a strong positive correlation with harvest index.

2.3.7. Straw Yield

Rajaul (2005) stated that straw yield was significantly affected due to varieties. The highest straw yield might be contributed by the taller plant and total tillers m-2 in improved varieties.

Ghosh et al. (2001) studied the performance of hybrid and high yielding cultivars and observed hybrids were superior over inbred in straw weight.

Hussain et al. (2009) revealed that delay in the transplanting beyond the last week of May resulted in significant reduction of grain yield of basmati rice. The magnitude of reduction of grain yield observed with week delay in planting beyond 25 May. Earlier planting dates of 25 May and 2 June produced higher straw yield and higher harvest index than delayed planting of 9 and 16 June.

From the brief reviews presented above it is evidently clear that short duration aman rice varieties are favorable compared to conventional aman varieties in respect to growth and yield of rice. Many researchers have reported the various positive impact of different aman rice varieties to improve yield, save inputs and natural resources and improve environment of conservational agriculture by adapting short duration aman. In addition, variety also has pronounced influence on growth and yield of aman rice. Thus, there is sufficient scope of investigating the yield performance of short duration aman rice varieties in favour of growth, yield, and yield contributing characteristics under the existing conditions of Polder ecosystem Bangladesh. The review of literature discussed above also indicates that interaction effect of date of transplanting and variety influenced crop characters, yield and yield parameters of aman rice under transplanted system of rice cultivation. Cultivation of suitable aman rice variety (ies) on optimum date of transplanting facilitates on- time rabi crop production before late boro sowing.

CHATEPR 3

MATERILAS AND METHODS

The experiment was conducted in polder 30 region (Fig. 1) at Batiaghata district of Khulna; southwestern coastal zone of Bangladesh during the period from July'2017 to January'2018.

3.1 Site Description

3.1.1. Geographical Location

The experiment was conducted in five different nearby sites considering each of them as replications. For better understanding about the experimental site has been shown in the Map (AEZ 13) of Bangladesh in Appendix I. The GPS reading of the experimental sites are given below:

Site	Latitude	Longitude
Hogolbunia	22°45′12.3″N	89°30′09.3″E
Basurabad	22°43′40.5″N	89°29′56.6″E
Fultala	22°42′58.6″N	89°31′27.2″E
Fultala Math	22°42′38.2″N	89°31′28.0″E
Tengramari	22°41′33.6″N	89°30′47.3″E

3.1.2. Climate

The experimental sites lie under the sub-tropical climate that are characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during Rabi season (October-March). High and low tides occur twice daily.

3.1.3 Soil

The soil of the experimental fields belongs to the general soil type, non-calcareous grey Floodplain soils (non saline) under Ganges Tidal Floodplain (AEZ 13). The land is located under flood level and sufficient sunshine was available during the experimental period. Soil pH ranged from 7.1-7.3 and had organic matter 0.78%. There was no additional water supplied in the experimental plots as tidal flooding is a common phenomenon in coastal zone. In the coastal zone, high and low tides occur twice daily. Soil samples from 0-15 cm depths were collected from the experimental field. The soil analyses were done at the Soil Resource and Development Institute (SRDI), Khulna. The physicochemical properties of the soil are presented in Appendix III.

3.2 Details of the Experiment

3.2.1. Treatments

There are two sets of treatments in the experiment. The treatments were variety which is considers as Factor A and different transplanting dates considers as Factor B.

The level of Factor A and B are as follows:

Factor A: Variety

BRRI dhan52 (V1)

Kumragor (V2)

Factor B: Transplanting Dates

S1- 1 July

S2- 10 July

S3-20 July

S4- 30 July

S5- 10 August

S6- 20 August

S7-30 August

3.2.2 Experimental Design

This experiment was set up in 5 sites (research hub) considering each as a replication of polder 30 region at Batiaghata, Khulna. The research sites were managed by borrowing lands from 5 farmers from five different research hubs so that the experiment result could easily be demonstrated to the local farmers for better transfer of knowledge. The whole plot of the farmers was taken for this study and the plot size varied accordingly. The experiment was laid out in a randomized complete block design (RCBD) with 5 dispersed replications. There were 14 treatment combinations. The total number of plots were 70. The size of the unit plot was 13.3m x 4m (Hogolbunia), 8.8m x 4m (Basurabad), 7.7m x 5.5m (Fultala), 8.75m x 5m (Fultala Moth) and 6.25m x 4.25m (Tengramari). The experimental units were separated by 1 m.

3.3 Crop/Planting material

Two rice varieties (BRRI dhan52 and Kumragor) were used as plant material.

3.3.1 Description of Variety:

BRRI Dhan52: BRRI Dhan52, a high yielding variety of Aman season was developed by Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. The pedigree line (IR-85260-66-654-Gaz2) of the variety was derived from a cross (BR11/IR40931-33-1-3-2) and was released in 2010 (BRRI). It is a submergence tolerant variety which can survive under water stagnant condition for a period of 12-15 days in case of sudden flood. It takes about 140- 145 days to mature. It attains at a plant height of 116-120 cm and at maturity the flag leaf remains green and erect. The grains are medium slender with light golden husks and kernels are white in color. This genotype is known for its strong stems, bold grains, with a 1000-grain weight of about 28 g, grain length of 5.3 mm, and grain width of 2.1 mm. The milled rice is medium fine and white. It is resistant to lodging and moderately resistant to blast (*Pyricularia oryzae*). The cultivar gives an average grain yield of 4.5-5 t ha^{-1}.

Kumragor: Kumragor is a popular traditional and local rice variety of the southern coastal zone of Bangladesh. It is specially a popular variety in many regions of Khulna division of Bangladesh. It takes about 155-160 days to mature. It attains at a plant height of 160-170 cm. The grains are slender with bold, thick, light golden husks and kernels are white in color. This genotype has comparatively weak stems, bold grains with a 1000-grains weight of about 26 g, grain length of 5.1 mm, and grain width of 2 mm. The milled rice is medium fine and white. It is susceptible to lodging and blast (*Pyricularia oryzae*). The cultivar gives an average grain yield of 2.5-3 t ha^{-1}.

3.4 Crop Management

3.4.1 Seedling Raising

3.4.1.1 Seed Collection

Healthy seeds of BRRI dhan52 was collected from the Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur. Kumragor was collected from local farmers.

3.4.1.2. Seed Sprouting

Seeds were selected by following specific gravity method. Seeds were immersed into water in a bucket for 24 hours. These were then taken out of water and kept tightly in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.4.1.3 Preparation of Seedling Nursery

Seedlings were raised on a high land in the farmer farm of Naharitola village, Batiaghata, Khulna. Each variety of seed was sown in separate beds. The nursery beds were prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible. Weeds were removed and irrigation was gently provided to the bed as and when needed. No fertilizer was used in nursery bed. Proper care was taken to raise seedlings in the nursery bed. The beds were kept weed free throughout the period of seedling raised.

3.4.1.4. Collection and Preparation of Initial Soil Sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves, stubbles etc were picked up and removed. Then the sample was air-dried and sieved through a sieve and stored in a clean plastic container for physical and chemical analysis.

3.4.1.5. Preparation of Experimental Land

The experimental field was first opened with a tractor drawn disc plough 15 days before transplanting. The land was ploughed by a two-wheel tractor, popularly known as power tiller. The land was puddled thoroughly by repeated ploughing and cross ploughing subsequently leveled by laddering. Immediately after final land preparation, the field layout was made (20 June 2017) according to experimental design. Individual plots were cleaned and finally leveled with the help of wooden planks so that no water pocket remained in the puddled field.

3.4.1.6. Fertilizer application

The experimental area was fertilized with 200, 100, 70, 60,and 10 kg of urea, triple superphosphate (TSP), Muriate of potash (MoP), gypsum and zinc sulphate as per hactre. The entire amounts of triple superphosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were applied at final land preparation according to the treatments. Urea was applied in two splits. The first one-half urea was top dressed at 30 days after transplanting (DAT). The rest of urea was top dressed at one week before panicle initiation stage.

3.4.1.7 The uprooting of seedlings

Twenty five days old seedlings were uprooted carefully and were kept in soft mud in shade. Seedlings were then transplanted as per experimental treatment on the well puddled plots.

3.4.1.8 Transplanting

Seedlings were transplanted on 1 July, 10 July, 20 July, 30 July, 10 August, 20 August and 30 august of 2017 in the well-puddled experimental plots. Plant spacing were given 20cm x 20cm for BRRI dhan52 and 30cm x 30cm (local farmer practice) for Kumragor varieties. Soil of the plots was kept moist without allowing standing water at the time of transplanting. Two seedlings for BRRI dhan52 and Kumragor varieties were transplanted hill-$^{1.}$

3.4.2. Inter Cultural Operations

3.4.2.1. Gap filling

Seedlings of some hills died off and these were replaced by gap filling after one week of transplanting with seedlings from the same source.

3.4.2.2 Weeding

To minimize weed infestation, manual weeding through hand pulling (due to heavy muddy soil) was done three times during entire growing season. The first weeding was done at 15 DAT followed by first top dressing of urea. The second and third weeding were done at 30 DAT and 45 DAT, respectively.

3.4.2.2 Irrigation and drainage

There was no additional water supplied in the experimental plots due to tidal flooding is a common phenomenon in coastal zone. In the coastal zone, high and low tides occur twice daily. The water depth of the experimental plot was measured daily. In July 2017, maximum water depth was 20.5 cm on 24th July and minimum was 3.02 cm on 30th July. In August 2017, maximum water depth was 7.55 cm on 10th August and minimum was 2.02 cm on 21-30 August. In September 2017, maximum water depth was 9.14 cm on 10th September and minimum was 1 cm on 1-7 September. In October 2017, maximum water depth was 30.025 cm on 10th October and minimum was 5.1 cm on 7th October in the experimental plots (Appendix viii). The highest water depth occurred due to intruded tidal flooding in the experimental area. In November 2017, maximum water depth of 9 cm was recorded in 6th November and minimum was 0 cm on 20-28 November (Appendix viii). The water depth was suddenly increased on 7th November due to tidal flood water entering into the experimental plots.

3.4.2.4 Plant protection measures

Plants were infested with rice stem borer (*Scirpophaga incertolus*) to some extent which was successfully controlled by applying Diazinon @ 10 ml 10 litre^{-1} water for 5 decimal lands when infestation was observed. At the grain filling stage plants were infested by false smut to some extent which was removed by manually cutting the infested panicles. To protect the crops from rat attack poly sheet was fixed around the whole experimental area.

3.4.2.5. Harvesting and Post-Harvest Operation

The crop in each plot was harvested separately on different dates at full maturity when 80% of the grains become golden yellow in color. The harvesting of BRRI dhan52 was done on November 17; November 24; December 2; December 7; December 17; December 25, 2017 and January 4, 2018 respectively. The local Kumragor variety was harvested on December 4; December 12; December 21; December 28, 2017; January 7, January 10 and January 15, 2018, respectively by cutting the hills above the soil from 4 m^2 harvest area of each plot. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The crops were threshed manually and then grains were cleaned. The grain and straw weights for each plot were recorded after proper sun drying and then converted into ton ha^{-1}. The grain yield was adjusted at 14% moisture level.

3.4.3 Recording of Data

Experimental data were determined from 30 days of growth duration and continued until harvest. Dry weights of plant were collected by harvesting twelve respective number of hills at flowering and maturity stages from the inner rows leaving border rows and harvest area for grain. The followings data were determined during the experimentation.

A. Crop Growth Characters

i. Plant height (cm) at 15 days interval
ii. Number of tillers hill^{-1} at 15 days interval
iii. Dry matter content at flowering and physiological maturity
iv. Time of flowering and maturity

B. Yield and Yield Components

i. Number of productive tillers hill^{-1}

ii. Number of non-productive tillers hill^{-1}

iii. Length of panicle (cm)

iv. Filled grains panicle^{-1}

v. Unfilled spikelet panicle^{-1}

vi. Weight of 1000-grains (g)

vii. Grain yield (t ha^{-1})

viii. Straw yield (t ha^{-1})

ix. Biological yield (t ha^{-1})

x. Harvest index (%)

3.4.4 Detailed Procedures of Recording Data

A brief outline on data recording procedure followed during the study is given below:

A. Crop Growth characters

i. Plant height (cm)

Plant height was measured at 30, 45, 60, 75, 90, 105 DAT and 120 DAT from twelve randomly pre-selected hills from each plot. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf height before heading, and to the tip of panicle after heading from the twelve randomly preselected hills.

i. Tillers hill^{-1}

Number of tillers hill^{-1} were counted at 30, 45, 60, 75, 90, and 105 DAT and 120 DAT from twelve randomly pre-selected hills of two spot in each unit plot and was expressed as number hill^{-1}. Only those tillers having three or more leaves were used for counting.

ii. Dry matter content hill^{-1} (g)

Dry matter content was measured at flowering and physiological maturity of rice.

The sub-samples of 5 hills plot^{-1} were uprooted from second line and oven dried until a constant level and then averaged the weight per hill.

iv. Time of flowering

Time of flowering (days) was recorded when about 50% of plants within a plot had externally visible anthers.

B. Yield and Yield Components

The sample plants of 4 m^2 were harvested randomly from each plot and tagged separately. Data on yield components were collected from the sample plants of each plot.

i. Effective tillers hill^{-1}

The panicles which had at least one grain was considered as effective tillers. The number of effective tillers form 12 hills was recorded and expressed as effective tillers hill^{-1}.

ii. Ineffective tillers hill^{-1}

The tillers having no panicle were regarded as ineffective tillers. The number of ineffective tillers of 12 hills was recorded and was expressed as ineffective tillers hill^{-1}

iii. Panicle length (cm)

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 12 panicles.

iv. Filled grains panicle^{-1}

Grains were considered as filled if kernel was formed. The number of total filled grains present on twelve panicles were recorded and finally averaged.

v. Unfilled grains panicle^{-1}

Unfilled grains means absence of kernel inside and such grains present in each of twelve panicles were counted and averaged.

vi. Total spikelet panicle^{-1}

The number of total filled and unfilled grains of a panicle gave the total number of spikelets panicle^{-1}.

vii. Weight of 1000 grains (g)

One thousand cleaned dried seeds were counted randomly from each sample and weighed by using a digital electric balance when the grains retained 14% moisture and the weight was expressed in gram.

viii. Grain yield (t ha^{-1})

Grain yield was determined from the central area of 4 m^2 from each plot and expressed as t ha^{-1} and adjusted with 14% moisture basis. Grain moisture content was measured by using a digital moisture tester.

ix. Straw yield (t ha^{-1})

Straw yield was determined from the central 4 m^2 area of each plot. After separating the grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

x. Biological yield (t ha^{-1})

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula and expressed onper hectare basis.

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

xi. Harvest index (%)

It denotes the ratio of economic yield (grain yield) to biological yield and was calculated with following formula (Donald, 1963; Gardener et al., 1985).

$$\text{HI (\%)} = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.5 Statistical Analysis of the Data

All the collected data were analyzed following the analysis of variance (ANOVA) technique and the mean differences were adjudged at 5% level of probability using LSD with a computer operated program named MSTATC.

CHAPTER 4

RESULTS AND DISCUSSION

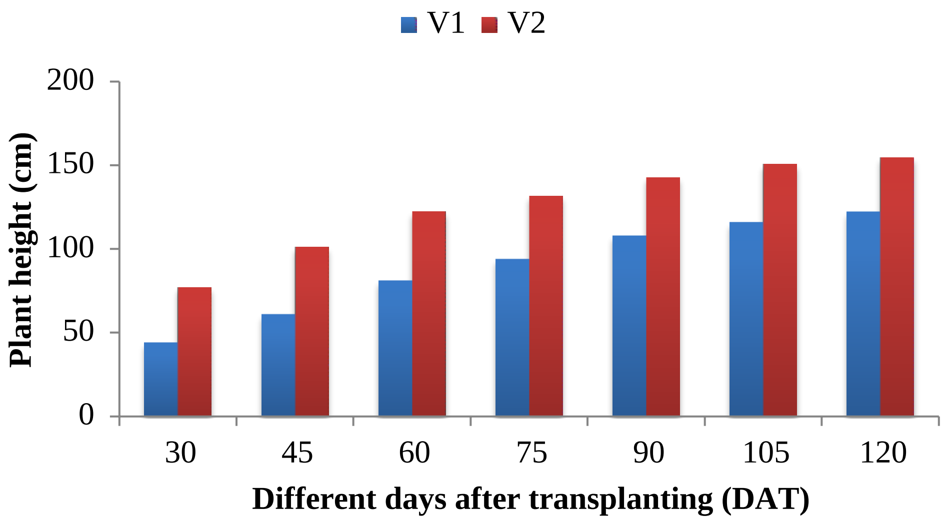
Results obtained from the present study regarding the effects of variety and different transplanting dates of aman rice and their interactions on the yield and yield components have been presented, discussed and compared in this chapter. The analytical results have been presented in Tables 1 through 7, Figures 1 through 18.

4.1 Crop growth characters

4.1.1 Plant height

4.1.1.1 Effect of variety

The plant height of aman rice was significantly influenced by different varieties at 30, 45, 60, 75, 90, 105 and 120 days after transplanting (DAT) (Figure 1). The results of the experiment revealed that, the local variety Kumragor (V_2) consistently gave the taller plant compared to BRRI dhan52 (V_1). At 30, 45, 60, 75, 90, 105 and 120 DAT the taller plant height (77.18 cm, 101.13 cm, 122.27 cm, 131.80 cm, 142.62 cm, 150.59 cm and 154.64 cm, respectively) was recorded from local variety Kumragor (V_2), on the other hand the shorter plant (44.07 cm, 60.81 cm, 80.89 cm, 94.12 cm, 108.00 cm, 115.62 cm and 122.35 cm, respectively) was from BRRI dhan52 (V_1). The plant height difference was very protruding between two rice varieties because plant height is a genetic trait where the local variety Kumragor distinctly taller than the modern variety BRRI dhan52. The findings were similar with the findings of Mohammad *et al.* (2014), Mannan *et al*. (2009), Rahman (2003), Khisha (2002), Shah and Yadav (2001),Om *et al.* (1998) and Angrish *et al.* (1997).

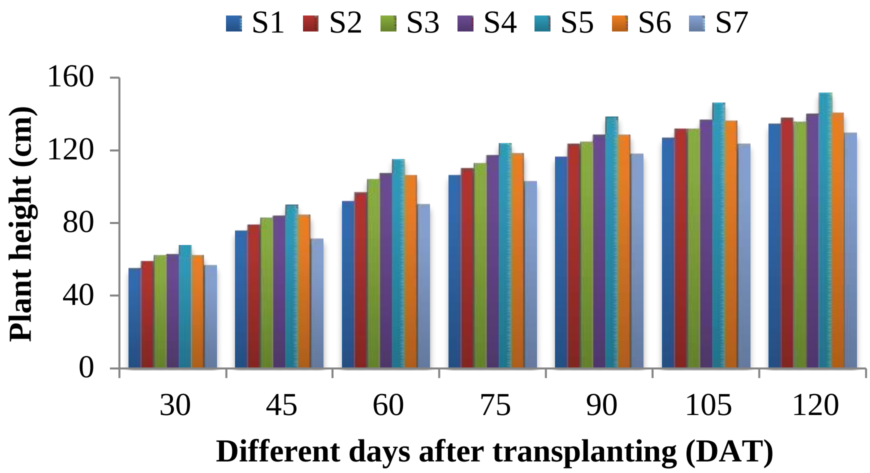


V_1= BRRI dhan52 and V_2 = Kumragor

Figure 1. Effect of variety on the plant height of aman rice at different days after transplanting (LSD $_{(0.05)}$ =2.75, 3.30, 4.34, 3.87, 4.92, 3.88 and 4.83 at 30, 45, 60, 75, 90, 105 and 120 DAT, respectively)

4.1.1.2 Effect of transplanting date

Significant variation of plant height was found due to different transplanting dates in all the studied durations (Figure 2). The results revealed that at 30 DAT, the tallest plant (67.78 cm) was obtained from the rice plant transplanted on 10 August (S_5) and the shortest plant (54.80 cm) was obtained from rice plant transplanted on 1 July (S_1) that was statistically similar with plant transplanted on 30 August (S_7) (56.60 cm) and plant transplanted on 10 July (S_2).The tallest plant (90.12 cm) was recorded at 45 DATfrom the rice transplanting on 10 August (S_5)which was statistically similar with rice transplanting on 20 August (S_6) (84.17 cm) and the shortest plant (71.40 cm) was obtained from rice transplanting on 30 August (S_7) which was statistically similar with rice transplanting on 1 July (S_1) (75.46 cm). At 60, 75, 90, 105 and 120 DAT the tallest plant (115.1 cm, 123.90 cm, 138.40 cm, 146.10 cm and 151.70 cm, respectively) were obtained from rice transplanting on 10 August (S_5) which was statistically similar with S_4 at 60 DAT and S_6 and S_4 at 75 DAT. Whereas the shortest plant (90.16 cm and 102.90 cm) were obtained from transplanting date S_7 at 60 and 70 DAT which were statistically similar with S_1 and S_2 from both transplanting date. At 90, 105 and 120 DAT the tallest plant (138.40 cm, 146.10 cm and 151.70 cm) were obtained from transplanting date S_5. At 90 DAT the shortest plant (116.30 cm) was obtained from transplanting date S_1 which was statistically similar with S_7, S_2 and S_3. Again the shortest plant (123.50 cm and 129.60 cm) were obtained from transplanting date S_7 which were statistically similar with S_1 at 105 DAT and S_1, S_3 and S_2 at 120 DAT. Short plant of the early planted crop were due to higher cloudy hours and less bright sunshine hour in the field that hampered crop growth and development. As the weather became cloud-free in mid-august than July, the photosynthesis rate increased which trigger the plant height. On the other hand, the plant height was decreasing with delaying the transplanting date. This might be due to the shorter vegetative period of late transplanted plant had less possibility to accumulate dry matter compare with the optimum transplanting date (10 August). The results are in conformity with the findings of Yadav and Abraham (2017), Faghani *et al.* (2011), Mannan *et al.* (2009), Safdar*et al.* (2008), Islam *et al.* (2008), Akram*et al.*, (2007), Salam *et al.* (2004),Chopra and Chopra (2004), Shah and Yadav (2001), Kumar *et al.*(1998), Vandala *et al*. (1994) and Gines *et al.* (1987). Islam *et al*. (2008) reported that, the maximum plant height (135 cm) was observed when the plant was transplanted on 10 August and the minimum plant height (128 cm) was observed when the plant was transplanted on 4 September.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 2. Effect of different transplanting dates on the plant height of aman rice at different days after transplanting (LSD $_{(0.05)}$ =5.12, 6.15, 8.09, 7.22, 9.18, 7.24 and 9.02 at 30, 45, 60, 75, 90, 105 and 120 DAT, respectively)

4.1.1.3. Interaction effect of variety and transplanting date

Significant interaction effect between the variety and transplanting date was observed throughout the growing period (Table 1). At 30, 45, 60, 75, 90, 105 and 120 DAT the tallest plant (87.57 cm, 110.20 cm, 137.10 cm, 147.80 cm, 160.00 cm, 170.10 cm and 171.30 cm, respectively) were recorded form local variety Kumragor (V_2) interaction with rice transplanting on 10 August (S_5) which were statistically similar with V_2S_4 at 30 DAT, V_2S_3, V_2S_4 and V_2S_6 at 45 DAT, V_2S_6 at 60 DAT, V_2S_6 and V_2S_4 at 90 DAT. The shortest plant (38.66 cm, 48.24 cm, 68.17 cm, 84.95 cm, 109.90 cm and 112.60 cm, respectively) were recorded from BRRI dhan52 (V_1) in combination with rice transplanting on 30 August (S_7) which were statistically similar with V_1S_1, V_1S_4, V_1S_3 and V_1S_2 at 30 DAT, V_1S_1 at 45 DAT, V_1S_1 and V_1S_2 at 60 and 75 DAT, V_1S_1, V_1S_2, V_1S_3, V_1S_4 and V_1S_6 at 105 and 120 DAT. At 90 DAT the shortest plant (99.99 cm) was recorded from BRRI dhan52 (V_1) in combination with rice transplanting on 1 July (S_1) which were statistically similar with V_1S_6, V_1S_2, V_1S_7, V_1S_3 and V_1S_4. Similar findings were reported by Safdar *et al*. (2008) who revealed that, fine grain rice genotype 99521 showed maximum plant height (195 cm) in 16th June transplanting date and minimum plant height was recorded in Super Basmati when transplanted on 16th May.

Table 1. Interaction effect of variety and different transplanting dates on the plant height of aman rice at different date of transplanting

Treatment	Plant height (cm) at different days after transplanting (DAT)						
combinations	30	45	60	75	90	105	120
V_1S_1	42.56 ef	55.46 fg	70.17 g	89.88 de	99.99 f	113.9 de	121.3 cd
V_1S_2	44.66 ef	61.48 def	74.62 fg	92.03 de	106.9 ef	113.3 de	121.9 cd
V_1S_3	44.32 ef	60.73 ef	84.35 ef	96.52 d	109.4 ef	116.2 de	123.0 cd
V_1S_4	43.94 ef	63.22 def	89.30 e	96.72 d	109.7 ef	118.3 de	122.9 cd
V_1S_5	47.98 e	70.02 d	93.05 e	100.0 d	116.8 de	122.1 d	132.0 c
V_1S_6	46.36 e	66.50 de	86.60 e	98.72 d	106.2 ef	115.7 de	122.7 cd
V_1S_7	38.66 f	48.24 g	68.17 g	84.95 e	107.0 ef	109.9 e	112.6 d
V_2S_1	67.04 d	95.46 c	113.3 cd	122.7 c	132.6 c	139.1 c	147.2 b
V_2S_2	73.11 cd	96.66 bc	118.4 b-d	127.6 bc	139.8 bc	149.5 b	153.7 b
V_2S_3	79.56 bc	104.6 ab	123.7 bc	128.8 bc	139.0 bc	147.2 bc	148.3 b
V_2S_4	80.87 ab	104.6 ab	125.3 b	137.4 b	147.2 ab	154.5 b	157.2 b
V_2S_5	87.57 a	110.2 a	137.1 a	147.8 a	160.0 a	170.1 a	171.3 a
V_2S_6	77.57 bc	101.8 a-c	125.9 ab	137.4 b	150.8 ab	156.7 b	158.3 b
V_2S_7	74.53 bc	94.57 c	112.1 d	120.8 c	129.0 cd	137.1 c	146.6 b
LSD $_{(0.05)}$	7.25	8.69	11.44	10.22	12.98	10.24	12.75
CV (%)	9.42	8.46	8.87	7.13	8.16	6.06	7.25

V_1= BRRI dhan52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

4.1.2 Number of tillers hill^{-1}

4.1.2.1 Effect of variety

The production of total number of tillers hill^{-1} of aman rice was significantly influenced by different varieties at 30, 45, 60, 75, 90, 105 and 120 DAT (Figure3). Local variety Kumragor (V_2) consistently gave the maximum number of tillers hill^{-1} throughout the investigation period. The result of the study revealed that, at 30, 45, 60, 75, 90, 105 and 120 DAT, the maximum number of tillers hill^{-1}(13.03, 19.36, 25.10, 23.89, 19.38, 16.45 and 13.71, respectively) were observed from the V_2 (Kumragor) and the minimum number of tillers hill^{-1} (9.76, 16.37, 21.44, 18.65, 14.60, 12.22 and 11.96, respectively) were obtained from the V_1 (BRRI dhan52). The probable reason of the differences in producing the tillers hill^{-1} could be the genetic make-up of the variety which was primarily influenced by heredity. The findings of Mannan *et al.* (2009), Shah and Yadav (2001), Bhowmick and Nayak (2000), Om *et al.* (1998) and Angrish *et al.* (1997) had similarity with these results. Mohammad *et al.* (2014) also reported that, the highest number of total tillers hill^{-1} was observed in BR11 (16.60) and the lowest one (10.30) was counted in Pajam.

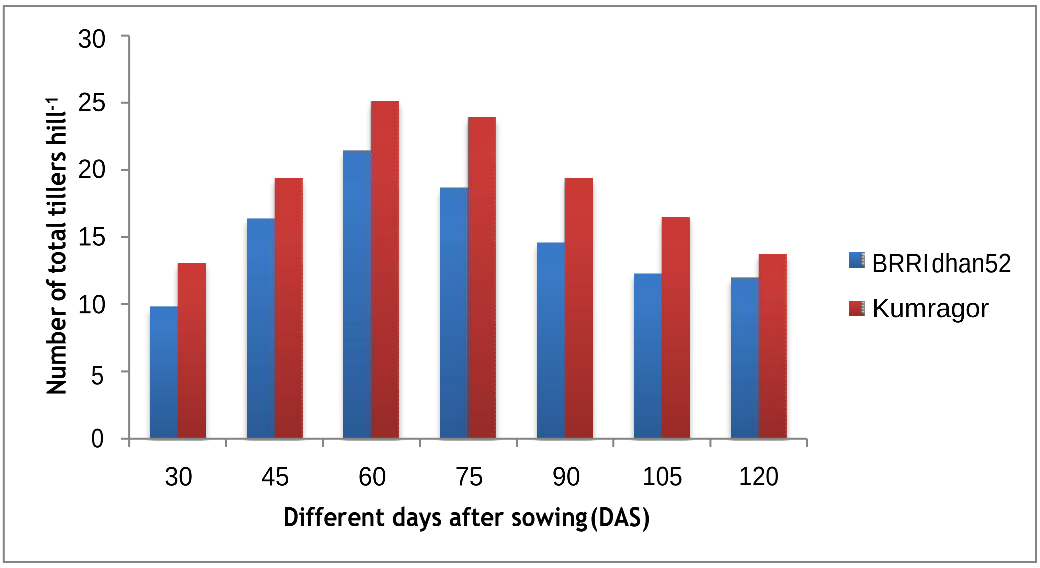
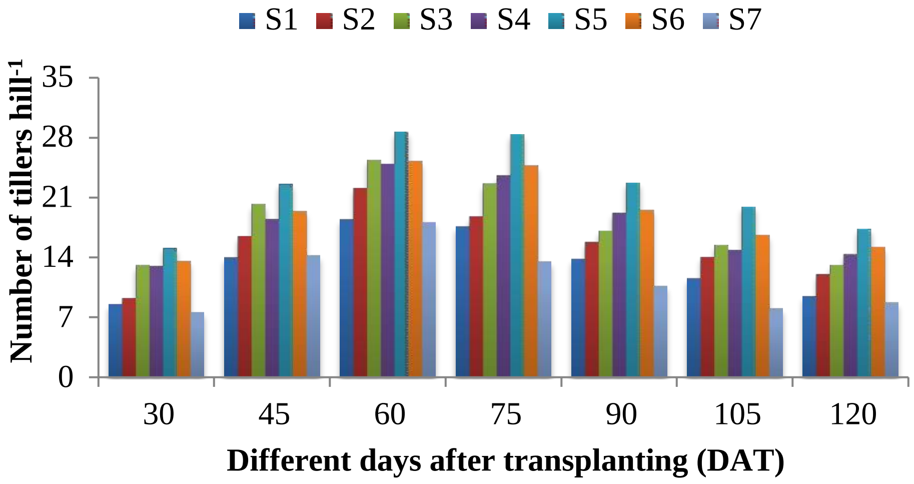


Figure 3. Effect of variety on the number of total tillers hill^{-1} of aman rice at different days after transplanting (LSD $_{(0.05)}$ =0.59, 0.86, 1.11, 1.06, 0.86. 0.71 and 0.63 at 30, 45, 60, 75, 90, 105 and 120 DAT, respectively)

4.1.2.2 Effect of transplanting date

The production of total tillers hill^{-1} was significantly influenced by different transplanting dates throughout the study period (Figure 4). The maximum number of tillers hill^{-1} was consistently observed from transplanting date S_5 (10 August) where as transplanting date S_7 (30 August) gave consistently poor total number f tillers hill^{-1} except at 45 DAT. Result showed that, the maximum number of tillers hill^{-1} (15.09, 22.58, 28.68, 28.36, 22.74, 19.91 and 17.32) were produced when the rice transplanting on 10 August (S_5) at 30, 60, 75, 90, 105 and 120 DAT, respectively and the minimum number of tillers hill^{-1} (7.55, 18.14, 13.51, 10.67, 7.98 and 8.70) were produced when the rice transplanting on 30 August (S_7) which were statistically similar withS_1 at 30, 60 and 120 DAT, respectively. At 45 DAT, the minimum number of tillers hill^{-1} (13.99) was produced when the rice transplanting on 1 July (S_1) which were statistically similar with S_7.The lower number of tillers hill^{-1} of the early planted crop were due to higher cloudy hours, less bright sunshine hour in the field that hampered crop growth and development. As the weather became cloud-free in mid-august than July, the photosynthesis rate increased which helped proliferate tiller production. On the other hand, tillers hill^{-1} was decreasing with the delaying the transplantation date. This might be due to the shorter vegetative period had fewer chance to produce higher tillers hill^{-1}. This finding corroborates with those findings of Mannan *et al.* (2009), Salam *et al.* (2004), Chopra and Chopra (2004) and Shah and Yadav (2001).Islam *et al.* (2008) found that, the maximum number of tillers hill^{-1} (11.10) was obtained when the rice transplanted at 10 August and the minimum number of tillers hill^{-1} (9.94) was obtained when the rice transplanted at 4 September.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 4. Effect of different transplanting dates on the number of tillers hill^{-1} of aman rice at different days after transplanting (LSD $_{(0.05)}$ =1.11, 1.60, 2.07, 1.98, 1.60, 1.33 and 1.18at 30, 45, 60, 75, 90, 105 and 120 DAT, respectively)

4.1.2.3. Interaction effect of variety and transplanting date

Interaction of variety and different transplanting date significantly influenced the production of total tillers hill^{-1} throughout the study period (Figure 2). The result of the experiment revealed that, treatment combination V_2S_5 gave the maximum number of tillers hill^{-1} (18.02, 24.00, 29.03, 31.13, 24.50, 22.23 and 18.80) at 30, 45, 60, 75, 90, 105 and 120 DAT, respectively which were statistically at par with V_2S_3 at 45 DAT; V_1S_5, V_2S_3, V_2S_4 and V_2S_6 at 60 DAT; V_2S_3 at 75 DAT. On the other hand treatment combination V1 S 7 gave the minimum number of tillers hill^{-1} (7.54, 15.70, 11.10, and 8.94 and 7.81) at 30, 60, 75, 90, and 105 DAT, respectively which were statistically similar with, V_2S_7, V_1S_1 and V_1S_2 at 30 DAT; V_1S_1 at 60, 75 and 90 DAT; V_2S_7 and V_1S_1 at 105 DAT. Again at 45 and 120 DAT the minimum number of tillers hill^{-1} (13.36 and 8.35, respectively) were obtained by treatment combinations V_1S_1 and V_2S_7, respectively which were statistically similar with V_1S_7, V_2S_1 and V_2S_7 at 45 DAT and V_1S_1, V_1S_7 and V_2S_1 at 120DAT.

Table 2. Interaction effect of variety and different transplanting dates on the number of tillers hill^{-1} of aman rice at different date of transplanting

Treatment combinations	Number of tillers hill^{-1} at different days after transplanting (DAT)						
	30	45	60	75	90	105	120
V_1S_1	7.88 f	13.36 f	16.24 e	13.68 Ef	10.94 fg	9.08 f	8.92 h
V_1S_2	8.80 ef	15.65 c-e	20.12 d	14.90 E	12.18 ef	11.06 e	11.15 fg
V_1S_3	10.10 de	16.58 cd	22.56 cd	16.01 E	13.81 e	12.63 de	12.16 ef
V_1S_4	10.21 de	16.21 cd	23.05 cd	24.01 b-d	16.87 d	13.31 d	13.05 de
V_1S_5	12.16 c	21.15 b	28.33 a	25.58 B	20.97 b	17.58 bc	15.84 b
V_1S_6	11.63 cd	17.86 c	24.08 bc	25.26 bc	18.46 cd	14.03 d	13.59 de
V_1S_7	7.54 f	13.77 ef	15.70 e	11.10 F	8.94 g	7.81 f	9.04 h
V_2S_1	9.06 ef	14.63 d-f	20.68 d	21.52 D	16.74 d	13.92 d	9.92 gh
V_2S_2	9.60 e	17.16 c	24.12 bc	22.51 cd	19.41 bc	17.04 c	12.85 de
V_2S_3	15.91 b	23.67 a	28.13 a	29.05 A	20.35 bc	18.17 bc	13.92 cd
V_2S_4	15.67 b	20.63 b	26.74 ab	22.94 b-d	21.58 b	16.43 c	15.50 bc
V_2S_5	18.02 a	24.00 a	29.03 a	31.13 a	24.50 a	22.23 a	18.80 a
V_2S_6	15.38 b	20.84 b	26.38 ab	24.14 b-d	20.68 bc	19.19 b	16.63 b
V_2S_7	7.57 f	14.58 d-f	20.58 d	15.92 e	12.41 ef	8.15 f	8.35 h
$LSD_{(0.05)}$	1.56	2.26	2.93	2.80	2.26	1.87	1.67
CV (%)	10.80	9.97	9.93	10.37	10.48	10.30	10.27

V_1= BRRI dhan52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

4.1.3 Dry matter weight hill^{-1}

4.1.3.1 Effect of variety

Variety significantly influenced the dry matter weight hill^{-1} at flowering and maturity stage of aman rice (Figure 5). The result showed that, Rice variety Kumragor (V_2) produced higher dry matter weight hill^{-1} (46.98 g and 72.65 g) at flowering and maturity stages, respectively compared to the high yielding variety BRRI dhan52 (37.85 g and 53.90 g). These findings were also in line with the findings of Mannan *et al.* (2009), Shah and Yadav (2001) and Angrish *et al.* (1997) who reported that, the dry matter hill^{-1} differed with the different rice varieties.

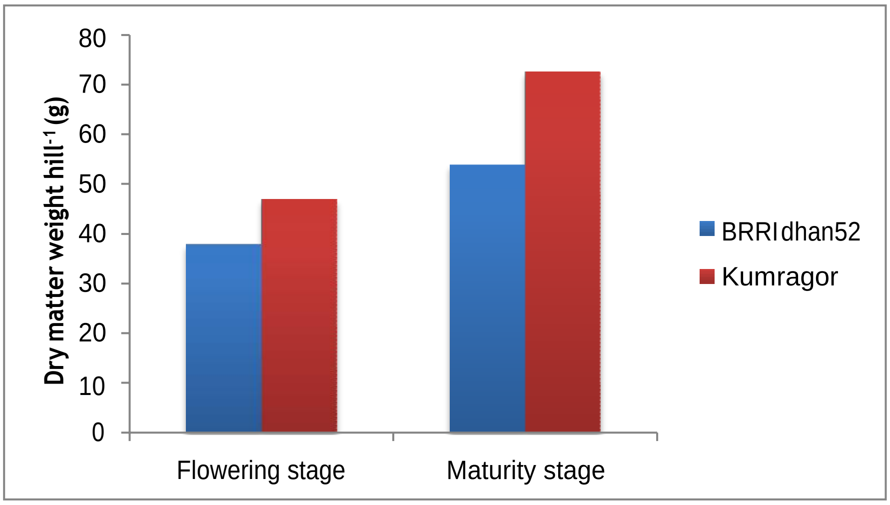
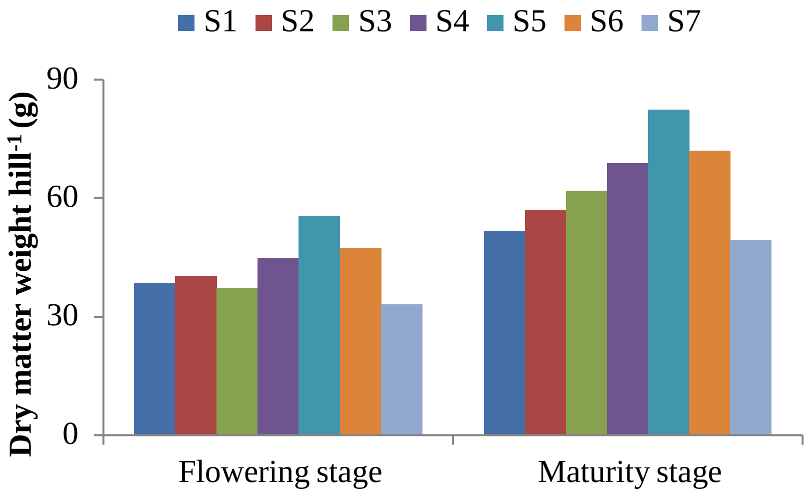


Figure 5. Effect of variety on the dry matter weight hill^{-1} of aman rice at flowering and maturity stage (LSD $_{(0.05)}$ =1.55 and 2.62 at flowering and maturity stage, respectively)

4.1.3.2 Effect of transplanting date

The dry matter weight hill^{-1} was significantly influenced by transplanting date both at flowering and maturity stage of aman rice (Figure6). At flowering and maturity stages the maximum dry matter weight hill^{-1}(55.50 gand 82.29 g, respectively) were recorded when the rice transplanted on 10 August (S_5) and the minimum dry matter weight hill^{-1} (33.10 g and 49.44 g, respectively) were recorded when the rice transplanted on 30 August (S_7) which was statistically at par with S_1 only at maturity stage. As the weather became cloud-free in mid-august than July, the photosynthesis rate was increased which helped more dry matter accumulation for consequence enhanced the dry matter weight hill^{-1} up to 10 August. On the other hand, the lower dry matter weight hill^{-1} of the early planted crop were due to higher cloudy hours, less bright sunshine hour in the field that hampered dry matter accumulation because under cloudy condition the photosynthesis activity reduces ultimately dry matter accumulation was lower on that condition. Moreover, the dry mater weight hill^{-1} was decreasing with the delaying the transplantation date. This might be due to the shorter vegetative period had fewer chance to accumulation of dry matter. The results were in conformity with the findings of Mannan *et al*. (2009), Islam *et al*. (2008), Salam *et al.* (2004), Chopra and Chopra (2004) and Shah and Yadav (2001) who reported that, the production of dry matter hill^{-1} was highest when the plant was transplanted at optimum time than the earlier and delayed transplantation.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 6. Effect of different transplanting dates on the dry matter weight hill^{-1} of aman rice at flowering and maturity stage (LSD $_{(0.05)}$ =2.89 and 4.88 at flowering and maturity stage, respectively)

4.1.3.3. Interaction effect of variety and transplanting date

Interaction effect of variety and transplanting date influenced the dry matter production of aman rice at flowering and maturity stage (Table 3). The maximum dry matter weight hill^{-1} (62.00 g and 95.80 g) were produced by rice variety Kumragor (V_2) with the combination of transplanting date S_5 at flowering and maturity stage, respectively. The minimum dry matter weight hill^{-1} (31.69 g) was produced by rice variety BRRI dhan52 (V_1) with the combination of transplanting date S_2 at flowering stage which was statistically identical with V_1S_1, V_2S_7, V_1S_3 and V_1S_7 treatment combinations and at maturity stage the minimum one (40.08 g) was produced by rice variety BRRI dhan52

(V_1) in combination with transplanting date S_7 (30 August) which was statistically identical with treatment combination V_1S_1.

Table 3. Interaction effect of variety and different transplanting dates on the dry matter weight hill^{-1} of aman rice at flowering and maturity stages

Treatment combinations	Dry matter weight hill^{-1} (g)	
	At flowering stage	At maturity stage
V_1S_1	32.02 f	42.25 ij
V_1S_2	31.69 f	48.84 hi
V_1S_3	33.35 f	52.63 gh
V_1S_4	40.00 e	60.72 f
V_1S_5	49.00 bc	68.77 de
V_1S_6	44.80 d	64.01 ef
V_1S_7	34.10 f	40.08 j
V_2S_1	45.04 cd	60.72 f
V_2S_2	49.00 bc	65.24 d-f
V_2S_3	41.10 de	71.00 cd
V_2S_4	49.60 b	76.97 bc
V_2S_5	62.00 a	95.80 a
V_2S_6	50.00 b	80.03 b
V_2S_7	32.09 f	58.80 fg
LSD $_{(0.05)}$	4.08	6.90
CV (%)	7.58	8.60

V_1= BRRI dhan52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

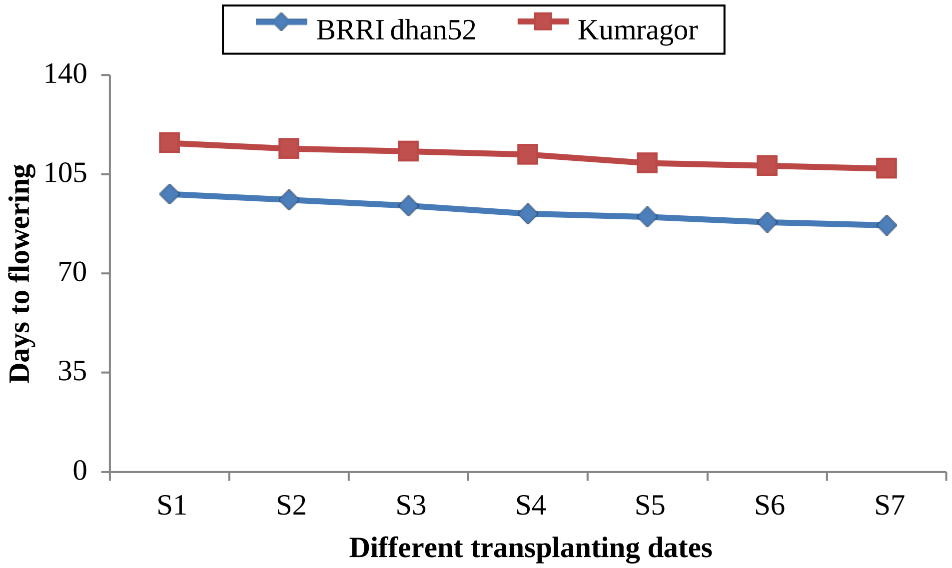
4.1.4 Days to flowering and maturity

4.1.4.1 Effect of variety

The flowering and maturity dates significantly varied between the varieties (Table 4), where the local variety Kumragor (V_2) needed longer time for flowering (111.29 days) and maturity (152.29 days) compared to the high yielding variety BRRI dhan52 (V_1) which needed (92.00 and 133.00 days) for flowering and maturity, respectively. Both the flowering and the maturity are genetical trait and they might be varied with the varietal variation.

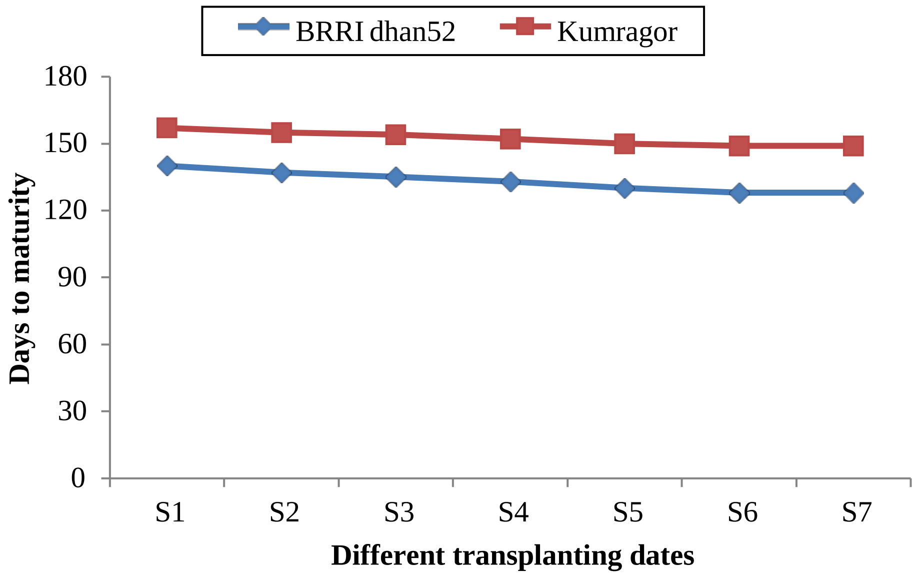
4.1.4.2 Effect of transplanting date

Different transplanting date significantly affected flowering and maturity time of both the varieties (Table 4). The transplanting date S_1 needed the longest duration for flowering (107.00 days) and for maturity (148.50 days) where the transplanting date S_7needed the shortest duration for flowering (97.00 days) which showed similarity with S_6 but for maturity both the transplanting dates S_7 and S_6 needed the shortest duration (138.50 days). Flowering is very important parameter as flowering leads to grain formation. In addition, flowering behavior serves as a criterion for identifying a rice genotype to be photoperiod sensitive. The crop transplanted on 1 July completed the active vegetative phase and passed the lag vegetative phase and wait for optimum short day length for floral induction and growth duration became longer (107 and 148.50 days, respectively) for flowering and maturity, while in late planted on 30 August crop, floral initiation occurred just after a minimum period required for the active vegetative phase due to the early fulfillment of the appropriate short day length and flowering and maturity occurred within 97 and 138.50 days, respectively. The photoperiodic response of rice made its timely floral initiation regardless of normal and late plantings. Similar response was also observed by Salam *et al.* (1992). However, too short growth duration may not produce high yields because of limited vegetative growth where time fortiller production is less. These results were in agreement with that of Mannan *et al.* (2009), Safdar *et al.* (2008), Rafiq *et al.*, (2005) and Maiti and Sen (2003) who found that the growth duration exhibited an increasing trend of early planted crop and decreasing trend of late planted crop. Shah and Yadav (2001) also reported that, the number of days from seeding to heading and maturity was recorded in the decline trend, as transplantation was delayed.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 7. Interaction effect of variety and different transplanting dates on the days to flowering of aman rice (LSD $_{(0.05)}$ = 1.90)



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 8. Interaction effect of variety and different transplanting dates on the days to maturity of aman rice (LSD $_{(0.05)}$ = 1.70)

Table 4. Influence of variety and different transplanting dates on the days to flowering and maturity of aman rice

Treatments	Days to flowering	Days to maturity
Effect of variety		
V_1	92.00 b	133.00 b
V_2	111.29 a	152.29 a
LSD $_{(0.05)}$	0.71	0.64
CV (%)	1.45	0.93
Effect of different transplanting dates		
S_1	107.00 a	148.50 a
S_2	105.00 b	146.00 b
S_3	103.50 c	144.50 c
S_4	101.50 d	142.50 d
S_5	99.50 e	140.00 e
S_6	98.00 f	138.50 f
S_7	97.00 f	138.50 f
LSD $_{(0.05)}$	1.32	1.19
CV (%)	1.45	0.93

V_1= BRRI dhan52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

4.1.4.3. Interaction effect of variety and transplanting date

Interaction effect of variety and transplanting date significantly influenced the flowering and maturity dates (Figure 7 and 8). Local variety Kumragor (V_2) which was transplanted on 1 July (S_1) required the highest duration for flowering (116 days) and maturity (157 days) whereas the high yielding variety BRRI dhan52 (V_1) which was transplanted on 30 August (S_7) required the lowest duration for flowering (87 days) which showed statistical similarity with BRRI dhan52 that was transplanted on 20 August (S_6) and in case of maturity BRRI dhan52 (V_1) which was transplanted on both 20 and 30 August (S_6 and S_7) needed the shortest duration (128 days).

4.2 Yield contributing characters

4.2.1 Number of effective tillers hill^{-1}

4.2.1.1 Effect of variety

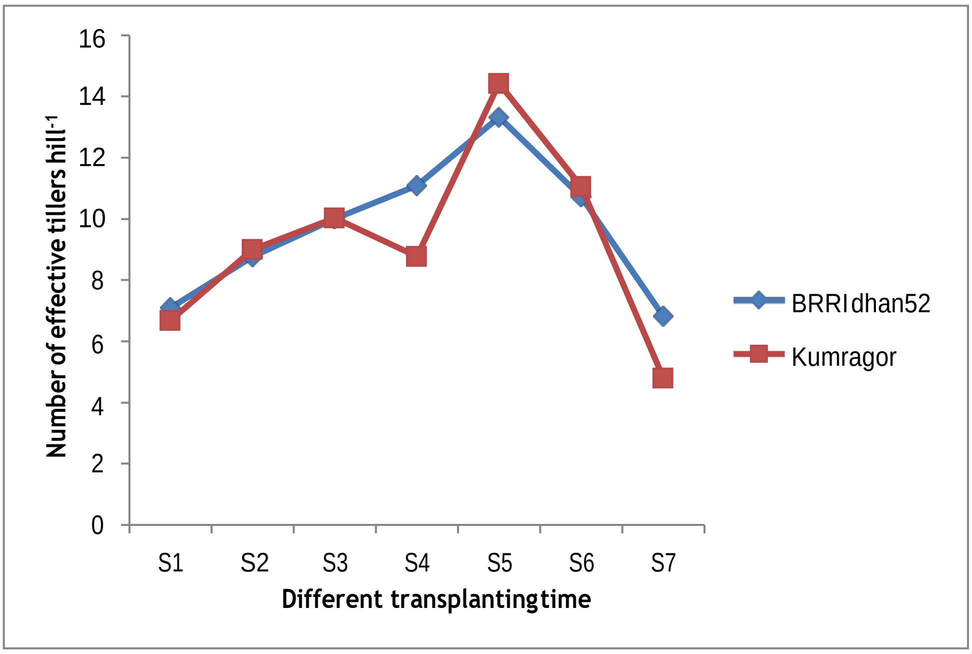
The number of effective tillers hill^{-1} was not significantly influenced by variety (Table 5). Numerically the maximum number of effective tillers hill^{-1} (9.69) was observed from BRRI dhan52 (V_1) and the minimum one (9.25) from Kumragor (V_2). This result was not coincide with the findings of Mukesh*et al*. (2013), Mannan*et al*. (2009), Shah and Yadav (2001), Bhowmick and Nayak (2000), BINA (1998) and Om and Desai (1998) who reported that, the number of effective tillers hill^{-1} varied with different rice varieties and the variation of effective tillers potentiality the genotypes might be due to the genetic makeup. Mohammad *et al.* (2014) revealed that the highest number of effective tillers hill^{-1} was produced by BR11 (12.4) and the lowest one (7.4) was produced by Pajam.

4.2.1.2 Effect of transplanting date

Transplanting date significantly influenced the number of effective tillers hill^{-1} of aman rice (Table 5). The maximum number of effective tillers hill^{-1} (13.88) was obtained from the transplanting date S_5 followed by S_6 (10.89) and the minimum number of effective tillers hill^{-1} (5.10) was obtained from the transplanting date S_7. 138.90 % more effective tillers hill^{-1} produced when the aman rice transplanted on 10 August over 30 August. Among yield components, number of effective tillers hill^{-1} is very important because the final yield is mainly a function of the number of panicles bearing tillers per unit area. This might be owing to longer growing period of the crop for better development of parts to allocate greater accumulation of photosynthates in early planting, resulting in the better development of growth and yield attributes (Yadav and Abraham, 2017 and Singh *et al.*, 2004). Similar trend was also observed by Mukesh *et al*. (2013), Mannan*et al*. (2009), Safdar *et al.* (2006), Hassan *et al*.(2003), Shah and Yadav (2001) and Islam *et al.* (1999) who noted the highest number of tillers hill^{-1} in early transplanted plant than the late transplanted one. Islam et al. (2008) reported that, the maximum number of effective tillers hill^{-1} (9.40) was observed with 10 August transplanting date and minimum number of effective tillers hill^{-1}(8.86) at 4 September. But too much early transplanting (1 July) also gave the lower number of effective tillers hill^{-1}. This might be due to lower sun shine hour and cloudy weather. Under these conditions, the photosynthetic ability of plant reduced lack of enough PAR (photosynthetic active radiation), for a consequence there was a reduction of effective tillers number hill^{-1}.

4.2.1.3. Interaction effect of variety and transplanting date

The number of effective tillers hill^{-1} was significantly influenced by the interaction effect of variety and transplanting date (Figure 9). The maximum number of effective tillers hill^{-1} (14.43) was obtained from the local variety Kumragor (V_2) which was transplanted on 10 August (S_5) and the minimum number of effective tillers hill^{-1} (4.80) was obtained from the same variety which was transplanted on 30 August (S_7).These results were in consonance with the findings of Gangwar and Sharma (1997) who also observed more number of effective tillers hill^{-1} in early transplanting than in late transplanting. This was due to the fact that rice genotypes planted earlier had longer period for their vegetative growth compared to those transplanted later. Safdar *et al.* (2008) found that, super basmati gave maximum number of effective tillers hill^{-1} (26.53) when transplanted on 1st June against minimum number of effective tillers hill^{-1} (9.57) shown by genotype 99417 in 16th June transplanting date.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 9. Interaction effect of variety and different transplanting dates on the number of effective tillers hill^{-1} of aman rice (LSD $_{(0.05)}$ = 1.22)

4.2.2 Number of ineffective tillers hill^{-1}

4.2.2.1 Effect of variety

The number of effective tillers hill^{-1} was significantly influenced by variety (Table 5). The maximum number of ineffective tillers hill^{-1} (2.02) was observed from Kumragor (V_2) and the minimum one (1.61) from BRRI dhan52 (V_1).

4.2.2.2 Effect of transplanting date

Transplanting date significantly influenced the number of ineffective tillers hill^{-1} of aman rice (Table 5). The maximum number of ineffective tillers hill^{1} (1.94) was obtained from the transplanting date S_7 which was statistically similar with rest of the transplanting dates except S_4 and S_6 and the minimum number of ineffective tillers hill^{-1} (1.71) was obtained from the transplanting date S_4 which was statistically similar with rest of the transplanting dates except S_7.

Table 5. Influence of variety and different transplanting dates on the number of effective and ineffective tillers hill^{-1} of aman rice

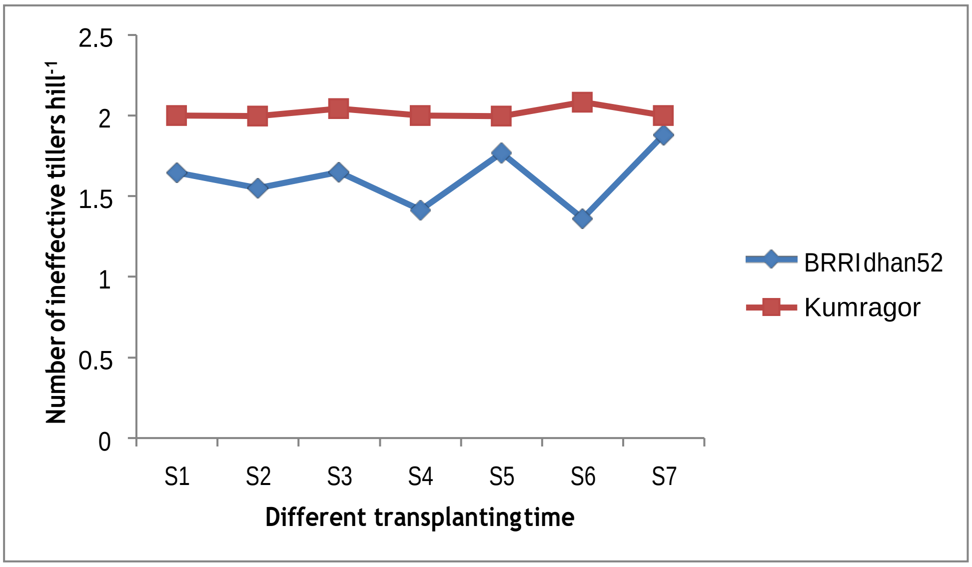
Treatments	No. of effective tillers hill^{-1}	No. of ineffective tillers hill^{-1}
Effect of variety		
V_1	9.69	1.61 b
V_2	9.25	2.02 a
LSD $_{(0.05)}$	NS	0.10
CV (%)	10.18	11.69
Effect of different transplanting dates		
S_1	6.89 e	1.83 ab
S_2	8.89 d	1.78 ab
S_3	10.02 c	1.85 ab
S_4	9.931 c	1.71 b
S_5	13.88 a	1.88 ab
S_6	10.89 b	1.72 b
S_7	5.810 f	1.94 a
LSD $_{(0.05)}$	0.87	0.19
CV (%)	10.18	11.69

^{NS} Non significant

V_1= BRRI dhan52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

4.2.2.3. Interaction effect of variety and transplanting date

The number of ineffective tillers hill^{-1} was significantly influenced by the interaction effect of variety and transplanting date (Figure 10). The maximum number of ineffective tillers hill^{-1} (2.08) was recorded from the local variety Kumragor (V_2) which was transplanted on 20 August (S_6) which was statistically at par with treatment combinations V_2S_3, V_2S_1, V_2S_4, V_2S_7, V_2S_2, V_2S_5 and V_1S_7 and the minimum number of ineffective tillers hill^{-1} (1.36) was recorded from the inbreed variety BRRI dhan52 (V_1) which was transplanted on 20 August (S_6) which showed similarity with the treatment combinations V_1S_4 and V_1S_2.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 10. Interaction effect of variety and different transplanting dates on the number of ineffective tillers hill^{-1} of aman rice (LSD $_{(0.05)}$ = 0.27)

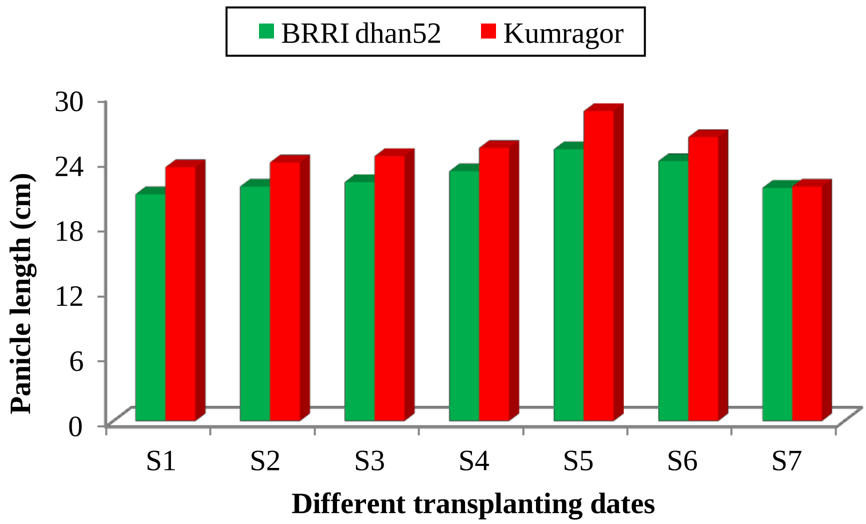
4.2.3 Panicle length

4.2.3.1. Effect of variety

The panicle length was varied significantly due to the varietal variation (Table 6). The maximum (24.76cm) and minimum (22.59 cm) panicle length was obtained from Kumragor (V_2) and variety BRRI dhan52 (V_1), respectively. Similar trend was also observed by Khalifa *et al.* (2014), Mohammad *et al.* (2014), Mukesh *et al.* (2013), Mannan *et al.* (2009), Abou Khalifa *et al.* (2005), Shah and Yadav (2001) and Sharief *et al*. (2000) revealed that, BR11 produced the longest panicle length (25.61cm) while Pajam produced the shortest panicle length (23.38 cm).

4.2.3.2 Effect of transplanting date

Panicle length significantly differed due to the variation of transplanting date (Table 6). The maximum (26.82 cm) panicle length was scored by transplanting date S_5which was statistically similar with S_6 and the minimum (21.56 cm) panicle length was scored by transplanting date S_7 which was statistically similar with S_1, S_2 and S_3.This showed that the early planting date enabled the plants to have longer time for growth before flowering. The early plants therefore had potentials for higher source capacity from which more dry matter could be produced for storage in the economic organs (panicle). The late planting coupled with early flowering did not allow enough time for vegetative growth and subsequently, there was decrease in panicle at the early planting (Vange and Obi, 2006). These findings were in conformity with the results of Mukesh *et al*. (2013), Mannan *et al*. (2009), Chopra and Chopra (2004), Chopra *et al.* (2003) and Islam *et al.* (1999).Islam *et al*. (2008) reported that, the maximum panicle length (23.00 cm) was obtained when the plant transplanted at 10 August and the minimum one (21.6 cm) was obtained at 4 September.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 11. Interaction effect of variety and different transplanting dates on the panicle length of aman rice (LSD $_{(0.05)}$ = 2.85)

4.2.3.3. Interaction effect of variety and transplanting date

Panicle length was significantly affected by the interaction effect of variety and transplanting date (Figure 11). The maximum panicle length (28.59 cm) was obtained from the treatment combination V_2S_5 followed by V_2S_6 (26.19 cm) and the minimum panicle length (20.91 cm) was gained from the treatment combination V_1S_1 which was statistically similar with V_1S_7, V_1S_2, V_1S_3, V_1S_4, V_2S_1 and V_2S_7.

4.2.4 Number of filled grains panicle^{-1}

4.2.4.1. Effect of variety

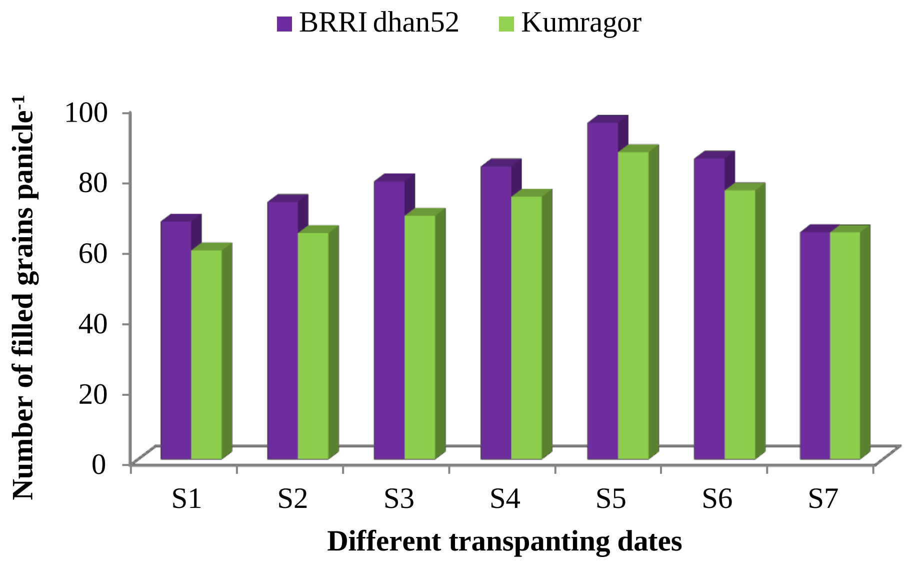
The number of filled grains panicle^{-1} differed significantly for variation of the variety (Table 6). The maximum number of filled grains panicle^{-1} (78.20) was found in the high yielding variety BRRI dhan52 and the lowest number of filled grains panicle^{-1} (70.66) was found from the local variety Kumragor. BRRI dhan52 produced 10.67% more filled grains panicle^{-1} over local variety Kumragor. These results were in agreement with those reported by Khalifa *et al*. (2014), Abou Khalifa *et al.* (2005), El-Khoby (2004), Shah and Yadav (2001), Bhowmick and Nayak (2000), Srivastava and Thipathi (1998), Song *et al.* (1990), Singh and Gangwer (1989).The highest number of grains panicle^{-1} (135.1) was found from BR11 the lowest results value was observed from Pajam (96.6) and (Mohammad *et al*., 2014).

4.2.4.2 Effect of transplanting date

The different transplanting date showed significant variation on the number of filled grains panicle^{-1} (Table 6). The highest number of filled grains panicle^{-1} (91.26) was obtained from the transplanting date S_5 and the lowest number of filled grains panicle^{-1} (63.34) was obtained from the transplanting date S_1 which was statistically similar with S_7 and S_2. Transplanting date S_5 produced 44.08% more filled grains panicle^{-1} over S_1. Vange and Obi (2006) reported that, the early planting date enabled the plants to have longer time for growth before flowering. The early plants therefore had potentials for higher source capacity from which more dry matter could be produced for storage in the economic organs (sink or panicle). The late planting coupled with early flowering did not allow enough time for vegetative growth and subsequently, there was decrease in grain filling period providing advantage of longer grain filling period to the early planting. Mannan *et al*. (2009) also reported that, higher number of grains panicle^{-1} was found in August planted crop probably due to the interaction of higher solar radiation associated with optimum temperature. On the other hand, grains panicle^{-1} was drastically reduced in late-planted. The obtained data were in a good harmony with those reported by Faghani *et al.* (2011), Shah and Yadav (2001), Ahmad *et al.* (1996) and Yoshida (1981) who concluded that, the number of filled grains panicle^{-1}was recorded in the decline trend, as transplantation was delayed. The highest number of filled grains panicle^{-1} (182) was obtained in 10 August transplanting date and the minimum one (176) was obtained in 4 September (Islam *et al.*, 2008). But Safdar *et al*. (2008), Gangwar and Sharma (1997) and Nazir (1994) found that, earlier transplanting in rice causes lower number of grains panicle^{-1} due to grain sterility because of high temperature at the time of grain maturation. Transplanting at its optimum time reduces grain sterility.

4.2.4.3. Interaction effect of variety and transplanting date

Interaction effect between variety and transplanting date was significant in respect of filled grains panicle^{-1} (Figure 12). The highest number of filled grains panicle^{-1} (94.43) was obtained from the treatment combination V_1S_5 followed by V_2S_5 (87.09) and the lowest number of filled grains panicle^{-1} (59.25) was obtained from the treatment combination V_2S_1 which was statistically at par with V_2S_2, V_2S_7, V_1S_7 and V_1S_1. Treatment combination V_1S_5 produced 59.38% more filled grains panicle^{-1} over treatment combination V_2S_1.These results was in conformity with the result of Mannan *et al.* (2009) who reported that, Basmati PNR and Basmati-D planted in August produced the maximum number of filled grains panicle^{-1} and it decreased progressively as the planting delayed beyond 7 September.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 12. Interaction effect of variety and different transplanting dates on the number of filled grains panice^{-1} of aman rice (LSD $_{(0.05)}$ = 8.79)

4.2.5 Number of unfilled grains panicle^{-1}

4.2.5.1. Effect of variety

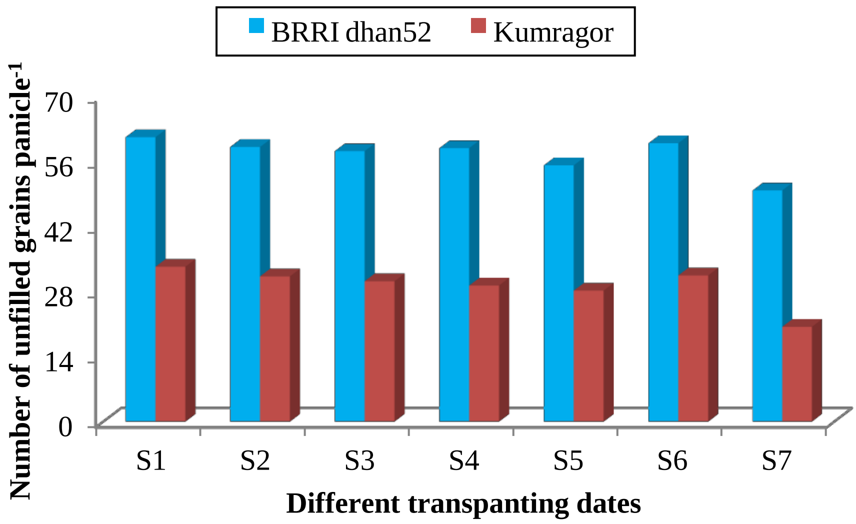
The unfilled grains panicle^{-1} was significantly differed between the local and inbred variety (Table 6). The result revealed that, the maximum number of unfilled grains panicle^{-1} (57.43) was counted in the high yielding variety BRRI dhan52 and the minimum number of unfilled grains panicle^{-1} (29.12) was counted in the local variety Kumragor. Similar findings were reported by Mannan *et al.* (2009), BRRI (2003) and Shah and Yadav (2001) who reported that, the number of unfilled grains pancle^{-1} differed due to varietal variation.

4.2.5.2 Effect of transplanting date

Analysis of variance showed that number of unfilled grains panicle^{-1} was statistically differed due to the different transplanting date (Table 6). The result showed that, the maximum number of unfilled grains panicle^{-1} (47.23) was counted when the rice was transplanted on 1 July which was statistically similar with rest of the transplanting dates except S_7 and S_5 and the minimum number of unfilled grains panicle^{-1} (35.04) was counted when the rice was transplanted on 30 August.The early planted crop was adversely affected by low temperature during panicle emergence to flowering stages. Similar results were found by Mannan *et al*. (2009) and Shah and Yadav (2001).

4.2.5.3. Interaction effect of variety and transplanting date

Unfilled grains panicle^{-1} was statistically influenced by interaction effect of variety and transplanting date (Figure 13). The highest (61.18) number of unfilled grains panicle^{-1} was recorded from the high yielding variety BRRI dhan52 which was transplanted on 1 July which was statistically at par with treatment combinations V_1S_6, V_1S_2, V_1S_4 and V_1S_3whereas the lowest number (20.37) was counted from the local variety Kumragor which was transplanted on 30 August.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 13. Interaction effect of variety and different transplanting dates on the number of unfilled grains panicle^{-1} of aman rice (LSD $_{(0.05)}$ = 5.00)

4.2.6 1000 grain weight

4.2.6.1. Effect of variety

The 1000 grain weight was significantly influenced by the varietal difference (Table 6). The highest 1000 grain weight (26.49 g) was obtained from the variety BRRI dhan52 and the lowest 1000 grain weight (24.54 g) was obtained from the local variety Kumragor. BRRI dhan52 produced 8% more 1000 gain weight over Kumragor. The collected data were in a good harmony with the findings of Khalifa *et al.* (2014), Mukesh *et al*. (2013), Abou Khalifa *et al*. (2005), Shah and Yadav (2001), Sharief *et al.* (2000), Shamsuddin *et al.* (1988) and Chowdhury *et al.* (1993) who reported that the 1000-grain weight varied among the varieties. Heavier grain was found in Basmati PNR followed by Basmati 375 and Basmati 370, while the lightest grain was found in Basmati-D (Mannan *et al.*, 2009). Safdar *et al*. (2008) concluded that, genotype 99417 produced 1000 grains with maximum weight (23.88 g) in contrast to genotype Bas 385 which produced minimum 1000 grains weight valued at 18.78 g. Mohammad *et al.* (2014) also found that, maximum 1000 grain weight (26.16 g) in BR11 and the minimum one (20.27g) was obtained from Pajam.

4.2.6.2 Effect of transplanting date

There was no significant effect among the transplanting date in respect of 1000 grain weight (Table 6) though the maximum 1000 grain weight (25.77 g) was obtained from the transplanting date S_5 and the minimum 1000 grain weight (25.32 g) was obtained from the transplanting date S_7.Thousand-grain weight, an important yield-determining component, is a genetic character least influenced by environment (Ashraf *et al*., 1999). Probably the grain filling was hampered due to late planting and decreased individual seed weight. Beside this, delayed transplanted plant had shorter vegetative period, so the dry matter accumulation was lower, ultimately there was less photosynthates accumulation from source to sink and finally reduce the seed size and lower the 1000 grain weight comparing with the optimum transplanting date (10 August). These findings were in conformity with those of Mukesh *et al.* (2013), Faghani *et al*. (2011), Mannan *et al.* (2009), Sabeti (2006), Pirdashti (2003) and Noorbakhshian (2003) who showed that the late transplanting date decreased 1000 grain weight. The highest 1000-grain weight (11.9 g) was obtained in transplanting date10 August whereas the lowest one (11.2 g) was obtained when the plant transplanted on 4 September (Islam *et al*., 2008). But Shah and Yadav (2001) reported that, transplanting date had no significant effect on 1000 grain weight of rice.

Table 6. Influence of variety and different transplanting dates on the number of filled and unfilled grains panicle^{-1}, panicle length and 1000 grain weight of aman rice

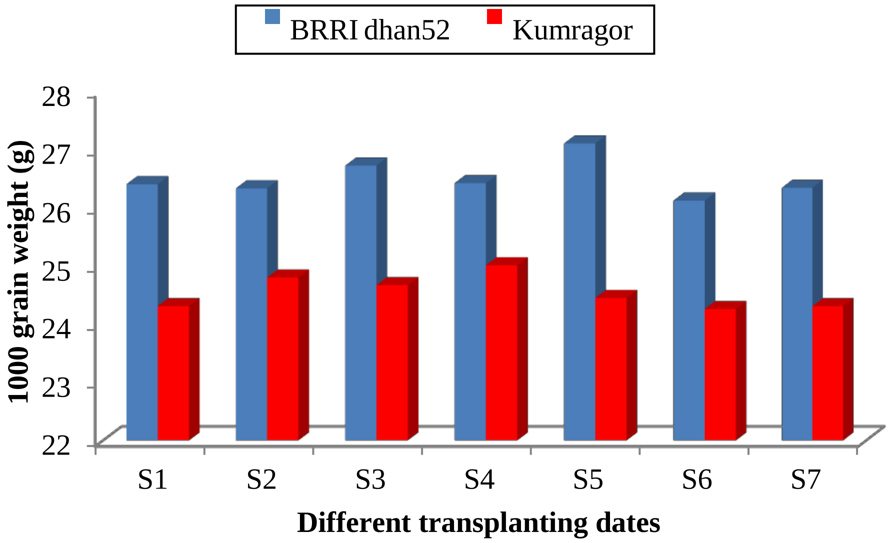
Treatments	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Panicle length (cm)	1000 grain weight (g)
Effect of variety				
V_1	78.20 a	57.43 a	22.59 b	26.49 a
V_2	70.66 b	29.12 b	24.76 a	24.54 b
LSD $_{(0.05)}$	3.33	1.89	1.08	0.65
CV (%)	9.31	9.10	9.49	5.27
Effect of different transplanting dates				
S_1	63.34 e	47.23 a	22.16 cd	25.35
S_2	68.57 de	45.15 ab	22.74 cd	25.56
S_3	73.95 cd	44.18 ab	23.23 b-d	25.69
S_4	78.75 bc	44.04 ab	24.12 bc	25.71
S_5	91.26 a	41.64 b	26.82 a	25.77
S_6	80.76 b	45.65 a	25.08 ab	25.19
S_7	64.39 e	35.04 c	21.56 d	25.32
LSD $_{(0.05)}$	6.22	3.53	2.02	NS
CV (%)	9.31	9.10	9.49	5.27

^{NS} Non significant

V_1= BRRI dhan52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

4.2.6.3. Interaction effect of variety and transplanting date

Interaction effect between variety and transplanting date had significant effect on the 1000 grain weight (Figure 14). The highest 1000 grain weight (27.10 g) was obtained from the V_1S_5 which was similar with V_1S_3, V_1S_4, V_1S_1, V_1S_2, V_1S_7 and V_1S_6. The lowest 1000 grain weight (24.26 g) was obtained from V_2S_6 treatment combination which was similar with V_2S_7, V_2S_1, V_2S_5, V_2S_3, V_2S_2 and V_2S_4. Treatment combination V_1S_5 produced 11.71% more 1000 grain weight over V_2S_6.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 14. Interaction effect of variety and different transplanting dates on the 1000 grain weight of aman rice (LSD $_{(0.05)}$ = 1.71)

4.2.7 Grain yield

4.2.7.1. Effect of variety

Grain yield was significantly influenced by the variety (Table 7). The highest grain yield (3.51 t ha^{-1}) was obtained from the high yielding variety BRRI dhan52 compared to the yield (2.17 t ha^{-1}) of local variety Kumragor. The improved variety (HYV) gave 61.75% higher yield than the local variety. This might be due to the genetical causes of the varieties. The grain yield of both the varieties reduced from their potential yield by 30% due to rodent attack. These findings are in conformity with the results obtained by Khalifa*et al*. (2014),Mukesh *et al*. (2013), Abou Khalifa *et al*. (2005), El-Khoby (2004), Khisha (2002), Shah and Yadav (2001), Patel (2000), Ghosh and Ganguly (1994) and Song *et al*. (1990). Mannan *et al*. (2009) reported that, among the test genotypes, the poor yield was observed in tall genotype Basmati 370 due to weak stem which was prone to pre-mature lodging susceptibility. Safdar *et al*. (2008) also reported that, genotype 99512 produced maximum paddy yield of 4.17 t ha^{-1}and the genotype 99417 gave minimum paddy yield (2.82 t ha^{-1}). Ahmad *et al*., (2006) claimed that among various basmati strains tested, 98316 and Super Basmati gave higher paddy yield. The findings of and Gangwar and Sharma (1997), Bali and Uppal (1995) and Munda *et al*.,

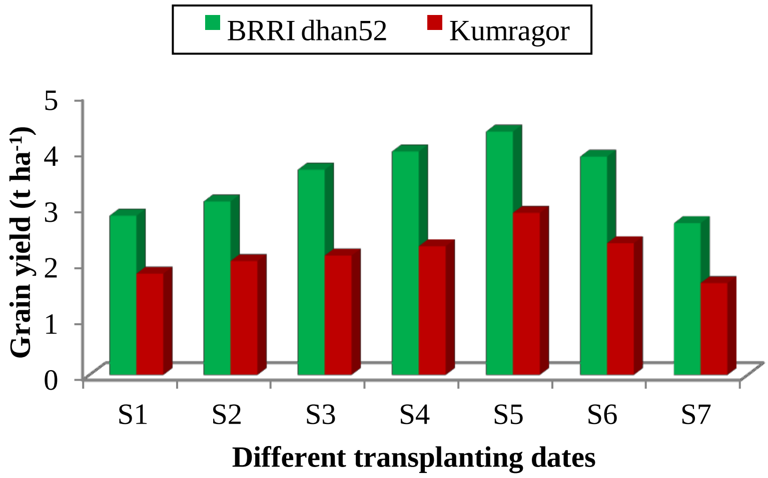
(1994) were also in the same direction. Mohammad *et al.* (2014) concluded that, BR11gave the higher grain yield (5.13 t ha^{-1}) and Pajam produced the lowest grain yield (3.54 t ha^{-1}).

4.2.7.2. Effect of transplanting date

Transplanting date had significant effect on grain yield (Table 7). Transplanting date S_5 produced significantly the highest grain yield (3.63 t ha^{-1}) that was followed by S_4 (3.15 t ha^{-1}) and S6 (3.13 t ha^{-1}). On the other hand, the lowest grain yield (2.18 t ha^{-1}) was produced by transplanting date S_7 which was similar with S_1 (2.33 t ha^{-1}). Transplanting date S_5 produced 66.51% higher grain yield over S_1.Grain yield is a function of interplay of various yield components such as number of effective tillers $hill^{-1}$, number of filled grains $panicle^{-1}$ and 1000-grain weight (Safdar *et al.* 2006 and Hassan *et al*., 2003). So, the obtaining results might be attributed to more number of effective tillers $hill^{-1}$, higher number of filled grains $panicle^{-1}$ and higher 1000 grain weight. The availability of more sunshine hours in mid-August was favorable to increase yield components (Mannan *et al*., 2009 and Singh and Zaman, 1991). These findings are in agreement with the observations made by BRRI (2003) for cultivation of aromatic fine rice in the aman season. The early-planted photoperiod sensitive crop was in the field for longer period to complete their life cycle which enhanced biomass production and tallness of plant resulting prone to lodge during grain filling period and decreased grain yield (Kropff and Spitters, 1991) Thus, grain yield of early-planted (1 July to 1 August) crop gave lower yield than the 10 August planted crop. It is natural process that the crop which had taken more number of days from transplanting to maturity might have a more vigorous and extensive root system, increased growth rate during vegetative growth, more efficient sink formation and greater sink size, greater carbohydrate translocation from vegetative plant parts to the spikelets during grain filling period. So, this might be the possible reason to have high yields in mid-August transplanting. Late planted (beyond 10August) crop showed lower number of effective tillers $hill^{-1}$, number of filled grains $panicle^{-1}$ and higher percentage of spikelet sterility that resulted in lower grain yield. Almost similar response was also noticed by Singh *et al.* (1997). It is clear from the result that most of the genotypes responded well in respect of grain yield when transplanted in August. Similar trend was also observed by Mannan and Siddique (1991) in aman season. The grain yield reduction of late planted crop was due to incomplete panicle emergence which increased the percentage of spikelet sterility. The results are in agreement with the findings of Yadav and Abraham (2017), Vishwakarma *et al.* (2016), Mukesh *et al.* (2013), Hussain *et al* .(2009), Safdar *et al.* (2008), Akram *et al*., (2007), Vange and Obi (2006), Shah and Yadav (2001), Bhurer *et al*. (1990), Acikgoz (1987), Chaudhry (1984), Koirala (1983) and Kunwar and Shrestha (1979). Islam *et al.* (2008) found that, the maximum grain yield (2.34 t ha^{-1}) was attained when the plant transplanted at 10 August and the minimum grain yield (2.13 t ha^{-1}) whenthe plant transplanted at 4 September.

4.2.7.3. Interaction effect of variety and transplanting date

Interaction between variety and transplanting date played an important role for promoting the yield. Grain yield was significantly influenced by the interaction effect of variety and transplanting date (Figure 15). Among the treatments, the highest grain yield was observed in inbred variety which was transplanted on 10 August (4.35 t ha^{-1}) followed by V_1S_4 (4.00 t ha^{-1}) and V_1S_6 (3.90 t ha^{-1}), whereas the lowest grain yield was observed in local variety which was transplanted on 30 August. The inbred variety which was transplanted on 10 August produced 165.24% more grain than the local variety which was transplanted on 30 August. Among planting dates, Hassan *et al*. (2003) obtained higher paddy yield of IR-6 on 25th of June as compared to 5th and 15th of July in Dera Ismail Khan. Pal *et al*. (1999) also reported higher paddy yield when transplanted on 15th or 29th of June.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 15. Interaction effect of variety and different transplanting dates on the grain yield of aman rice (LSD $_{(0.05)}$ = 0.22)

4.2.8 Straw yield

4.2.8.1. Effect of variety

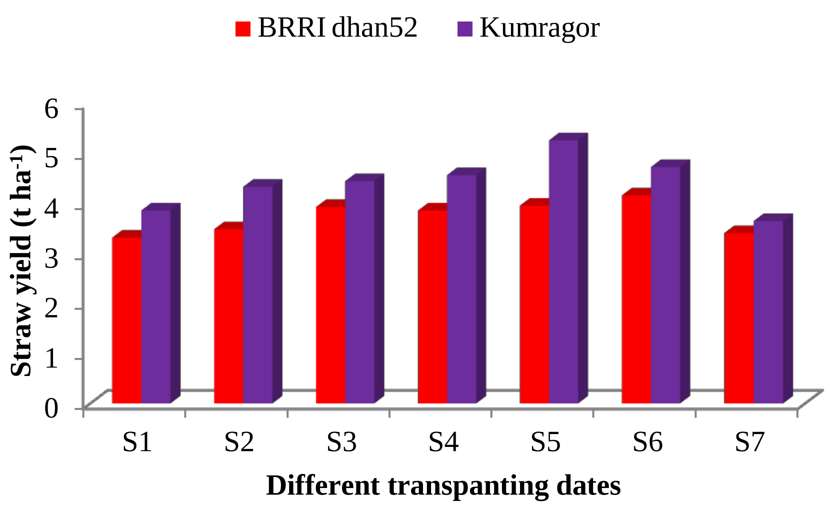
Straw yield was significantly affected by the variety (Table 7). The higher straw yield (4.40 t ha^{-1}) was obtained from the local variety Kumragor compared to the other variety BRRI dhan52 (3.72 t ha^{-1}). The straw yield was 18.28% higher in the inbred variety compared to that of local one. This result was similar with the findings of Mohammad *et al.* (2014) who reported that, the highest straw yield (5.90 t ha^{-1}) was produced by BR11 while the lowest straw yield (3.99 t ha^{-1}) was recorded from Pajam. Similar results also obtained by Patel (2000) and Chowdhury *et al.*(1993).

4.2.8.2 Effect of transplanting date

There was significant difference observed among the transplanting dates in respect of straw yield (Table 7). The result revealed that, the highest straw yield (4.60 t ha^{-1}) was obtained from the transplanting date S_5 which was identical with transplanting date S_6 (4.44 t ha^{-1}) and the lowest straw yield (3.52 t ha^{-1}) was obtained from the transplanting date S_7 which was identical with transplanting date S_1 (3.58 t ha^{-1}).The straw yield decreased with the advancement of planting date. The crop planted on 10 August had longer vegetative growth period that produced higher amount of biomass resulting in higher straw yield than the late-planted crop (30 August). Too much early planted crop (1 July) also gave lower straw yield, this might be due to lower sun shine hour, cloudy weather in the standing field which reduce the photosynthetic potentiality of plant. These results are in conformity with the results of Mannan *et al.* (2009), Chopra and Chopra (2004) and Salam *et al.* (2004). Islam *et al.* (2008) confirmed that, the highest straw yield was obtained (5.84 t ha^{-1}) in transplanting date 10 August and the lowest straw yield (5.58 t ha^{-1}) was obtained at 4 September.

4.2.8.3 Interaction effect of variety and transplanting date

Interaction effect between variety and transplanting date had significant influence in the straw yield of aman rice (Figure 16). Result showed that, the maximum straw yield (5.25 t ha^{-1}) was recorded from rice variety Kumragor along with the transplanting date S_5. The minimum straw yield (3.31 t ha^{-1}) was obtained from inbreed variety BRRI dhan52 along with transplanting date S_1 which was similar with the combinations of V_1S_7, V_1S_2 and V_2S_7.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 16. Interaction effect of variety and different transplanting dates on the straw yield of aman rice (LSD $_{(0.05)}$ = 0.37)

4.2.9 Biological yield

4.2.9.1 Effect of variety

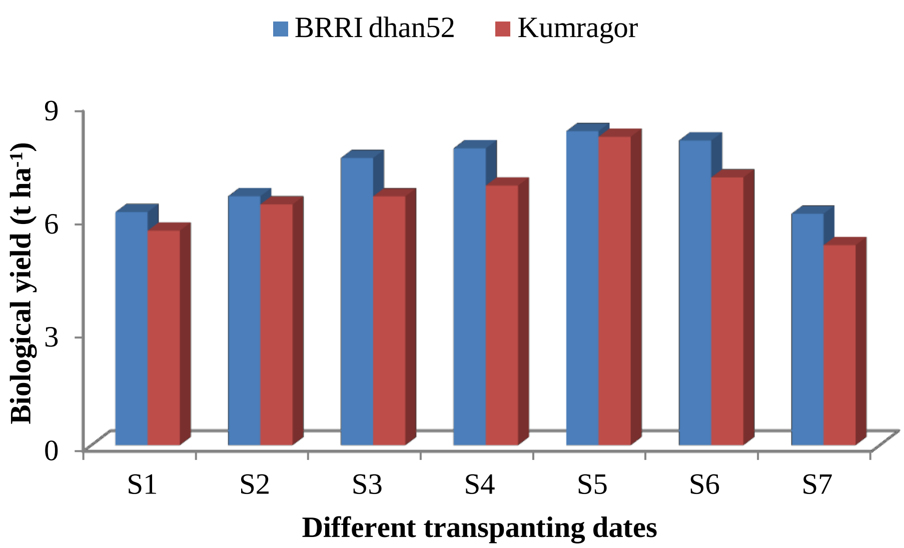
Variety had effect on biological yield of aman rice (Table 7). The result of the investigation revealed that, the maximum biological yield (7.24 t ha^{-1}) was found from the high yielding variety BRRIdhan52 and the lowest biological yield (6.57 t ha^{-1}) was found from the local variety Kumragor. This result was in line with the findings of Mohammad *et al.* (2014) who found that the highest biological yield (11.04 t ha^{-1}) due to highest grain and straw yield was recorded from BR11and the lowest biological yield (7.53 t ha^{-1}) was obtained from Pajam.

4.2.9.2 Effect of transplanting date

There was significant difference among the transplanting dates observed in respect of biological yield (Table 7). The highest biological yield (8.23 t ha^{-1}) was found when the rice was transplanted on 10 August and the lowest biological yield (5.70 t ha^{-1}) was found when the rice was transplanted on 30 August which was statistically similar with transplanting date 1 July.

4.2.9.3 Interaction effect of variety and transplanting date

Interaction effect between variety and transplanting date was significant in respect of biological yield (Figure 17). The highest biological yield (8.30 t ha^{-1}) was recorded the inbred variety transplanted on 10 August which was statistically similar with treatment combinations V_2S_5, V_1S_6 and V_1S_4 and the lowest biological yield (5.28 t ha^{-1}) was recorded from local rice variety Kumragor transplanted on 30 August which was statistically similar with treatment combination V_2S_1.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 17. Interaction effect of variety and different transplanting dates on the biological yield of aman rice (LSD $_{(0.05)}$ = 0.56)

4.2.10 Harvest index

4.2.10.1 Effect of variety

Harvest index was significantly influenced by the variety (Table7).The highest harvest index (48.30%) was found from the high yielding variety BRRI dhan52 and the lowest harvest index (32.88%) was found from the local variety Kumragor. The harvest index was 46.90% higher in the inbreed variety compared to the local variety. Similar findings was also reported by Mohammad *et al*. (2014) who concluded that, the highest harvest index (50.06%) was recorded from BRRI dhan40. The lowest one (46.94 %) was obtained from Pajam.

4.2.10.2 Effect of transplanting date

Transplanting date produced significant differences in respect of harvest index (Table 7). The highest harvest index (44.01%) was found from the transplanting date 10August which was statistically identical with transplanting date 1 and 20 August, on the other hand the lowest harvest index (37.76%) was found from the transplanting date 30 August which was statistically identical with all other transplanting dates except 30 July and 10 August.

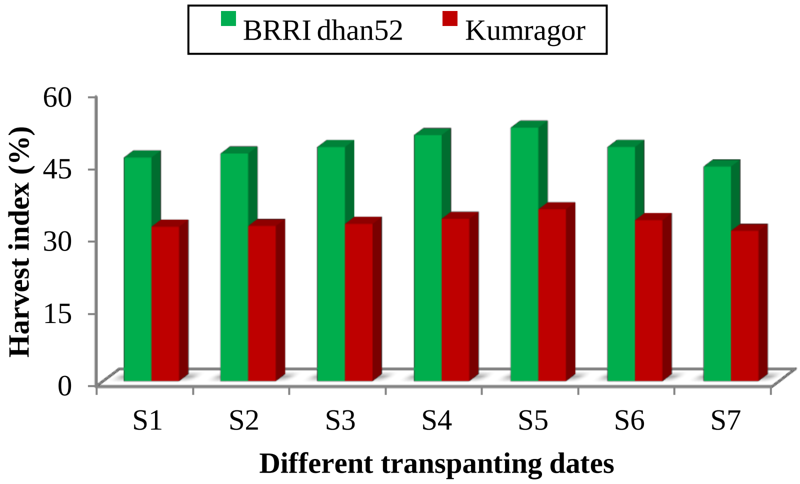
Table 7. Influence of variety and different transplanting dates on grain yield, straw yield, biological yield and harvest index of aman rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Effect of variety				
V_1	3.51 a	3.72 b	7.24 a	48.30 a
V_2	2.17 b	4.40 a	6.57 b	32.88 b
LSD $_{(0.05)}$	0.08	0.14	0.21	1.80
CV (%)	6.22	7.14	6.34	9.20
Effect of different transplanting dates				
S_1	2.33 e	3.58 d	5.91 e	39.11 bc
S_2	2.57 d	3.90 c	6.47 d	39.61 bc
S_3	2.90 c	4.18 b	7.08 c	40.49 bc
S_4	3.15 b	4.21 b	7.36 bc	42.26 ab
S_5	3.63 a	4.60 a	8.23 a	44.01 a
S_6	3.13 b	4.44 ab	7.57 b	40.88 ac
S_7	2.18 e	3.52 d	5.70 e	37.76 c
LSD $_{(0.05)}$	0.16	0.26	0.39	3.35
CV (%)	6.22	7.14	6.34	9.20

V_1= BRRI dhan 52 and V_2 = Kumragor; S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

4.2.10.3 Interaction effect of variety and transplanting date

Interaction effect between variety and transplanting date was significant in respect of harvest index (Figure 18). The highest harvest index (52.46%) was recorded from the inbreed variety transplanted on 10 August which showed similarity with the same variety transplanted on 20, 30 July and 20 August. The lowest harvest index (31.10%) was found from the local variety transplanted on 30 August which showed similarity with the same variety along with all the transplanting dates.



S_1=1 July, S_2=10 July, S_3=20 July, S_4= 30 July, S_5=10 August, S_6=20 August and S_7= 30 August

Figure 18. Interaction effect of variety and different transplanting dates on the harvest index of aman rice (LSD $_{(0.05)}$ = 4.74)

CHAPTER 5

SUMMARY AND CONCLUSIONS

A field experiment was conducted on the farmers' fields in polder 30, Batiaghata, Khulna during July to January 2018 in order to study the influence of different transplanting dates on the performances of aman rice under tidal ecosystem prevailing in the polders of the south-western coastal zone of Bangladesh. The experiment consisted of two level of treatments viz. variety and transplanting dates. The experiment was comprised of two rice varieties viz. BRRI dhan52 (V1) and Kumragor (V2) (local T. aman rice) and seven transplanting dates viz. 1 July (S1), 10 July (S2), 20 July (S3), 30 July (S4), 10 August (S5), 20 August (S6), 30 August (S7). The experiment was laid out in a randomized complete block design with five dispersed replications. There were 14 treatment combinations. The total number of plots were 70. The size of the unit plot was 13.3m x 4m (Hogolbunia), 8.8m x 4m (Basurabad), 7.7m x 5.5m (Fultala), 8.75m x 5m (Fultala Moth) and 6.25m x 4.25m (Tengramari). The distance between each plot was 1m. The crop of each plot was harvested separately on different dates at full maturity when 80% of the grains become golden yellow in color. Crop cut was taken by cutting the hills above the soil from 4 m^2 harvest area of each plot. The data on crop growth parameters like plant height, number of tillers hill^{-1}, leaf area index, dry matter and time of flowering and maturity were recorded at different growth stages. Yield parameters like number of effective tillers hill^{-1}, ineffective tillers hill^{-1}, panicle length, and number of grains panicle^{-1}, filled and unfilled grains panicle^{-1}, 1000-grains weight, grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}), harvest index (%) were recorded after harvest. The data were collected from the randomly selected twelve hills from each plot. All the relevant data were analyzed following the analysis of variance (ANOVA) technique and the mean differences were adjudged at 5% level of probability using LSD from MSTATC.

Results showed that plant height, number of total tillers hill^{-1}, number of effective tillers h i l l $^{-1}$, dry matter, growth duration, number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, grain yield, straw yield, biological yield, harvest index, and field duration were significantly influenced by varieties. The rapid increase in plant height and dry weight was higher in the BRRI dhna52 compared to the Kumragor, however, at harvest it was also higher in the BRRI dhna52. The higher number of tillers at all the growth stages and at harvest was recorded in BRRI dhan52. Again, BRRI dhan52 needed shorter duration (131 days) for flowering and maturity compared to the variety Kumragor (146 days). BRRI dhan52 produced maximum number of effective tillers hill^{-1} and longer panicle compared to Kumragor. The higher number of filled grains panicle^{-1} (78.20) was obtained from BRRI dhan52 and the lower number of grains panicle^{-1} (70.66) was obtained from Kumragor. The higher weight of 1000-grains (26.49g) was obtained from BRRI dhan52 and the higher biological yield (7.24 t ha^{-1}), whereas, Kumragor produced the lower grain yield (2.17 t ha^{-1}), lower straw yield (4.40 t ha^{-1}) and the lower biological yield (6.57 t ha^{-1}). The grain yield increase was 61.75% higher in BRRI dhan52 than Kumragor. The maximum harvest index (48.30) was found from BRRI dhan52. The grain yield of both of varieties were reduced by 30% from potential yield due to rodent attack.

Transplanting date also significantly influenced all growth and yield attributes. The results revealed that transplanting date of 10 August produced the highest plant height and number tiller hill^{-1}at all the growth stages and at harvest. At harvest, both the varieties, BRRI dhan52 and Kumragor produced highest dry weight transplanted on 10 August. BRRI dhan52 transplanted on 1 July needed the longest duration for flowering and maturity, whereas, the lowest duration for flowering and maturity was observed for both the varieties transplanted on 10 August. The highest filled grains panicle^{-1} (91.26) was obtained on August 10 transplanting and the lowest number of filled grains panicle^{-1}(63.34) was recorded with July 1 transplanting. The maximum number of unfilled grains panicle^{-1} (47.23) was obtained on the transplanting date 1 July whereas, the transplanting date 30 August yielded the minimum number of unfilled grains panicle^{-1} (35.04). There was no significant difference of 1000-grains weight among the transplanting dates. Transplanting date 10 August showed the highest plant height (151.7cm); highest number of effective tiller shill^{-1} (17.32), grain yield (3.63tha^{-1}), straw yield (4.60tha^{-1}), biological yield (8.23tha^{-1}) and harvest index (44.01%). The plant height (129cm), number of effective tillers hill-^{1} (8.69), grain yield (2.18 tha^{-1}), straw yield (3.52tha^{-1}), biological yield (5.70tha^{-1}) and harvest index (37.70%) were lowest with August 30 transplanting.

Interaction effect of variety and transplanting date also significantly affected growth as well as yield and yield contributing characters. The tallest plant height was initially found in Kumragor. In the later stages, the maximum number of tillers hill^{-1} was obtained from the BRRI dhan52 transplanted on 10 August. At harvest, the highest effective number of tiller hill^{-1} (15.84) and highest grain yield (4.35 t ha^{-1}), straw yield (3.95 t ha^{-1}) was obtained from BRRI dhan52 transplanted on 10 August. On the other hand, t he local variety Kumragor transplanted on 30 August has given the lowest grain yield (1.64 t ha^{-1}) as well as shortest field duration (129 days). All the varieties have shown drastic yield reduction in respect of both grain and straw yield transplanted on 1 July and 30 August.

Based on the results of the present study, the following conclusions may be drawn-

- ❖ BRRI dhan52 performance was significantly superior in aman season under transplanted system of cultivation in polder ecosystem.
- ❖ Optimum transplanting date in polder ecosystem for highest grain yield of aman rice was 10 August.
- ❖ Both the early and late transplanting gave the lowest yield in aman rice. Drastic decrease of yield was showed on both the transplanting date 1 July and 30 August.

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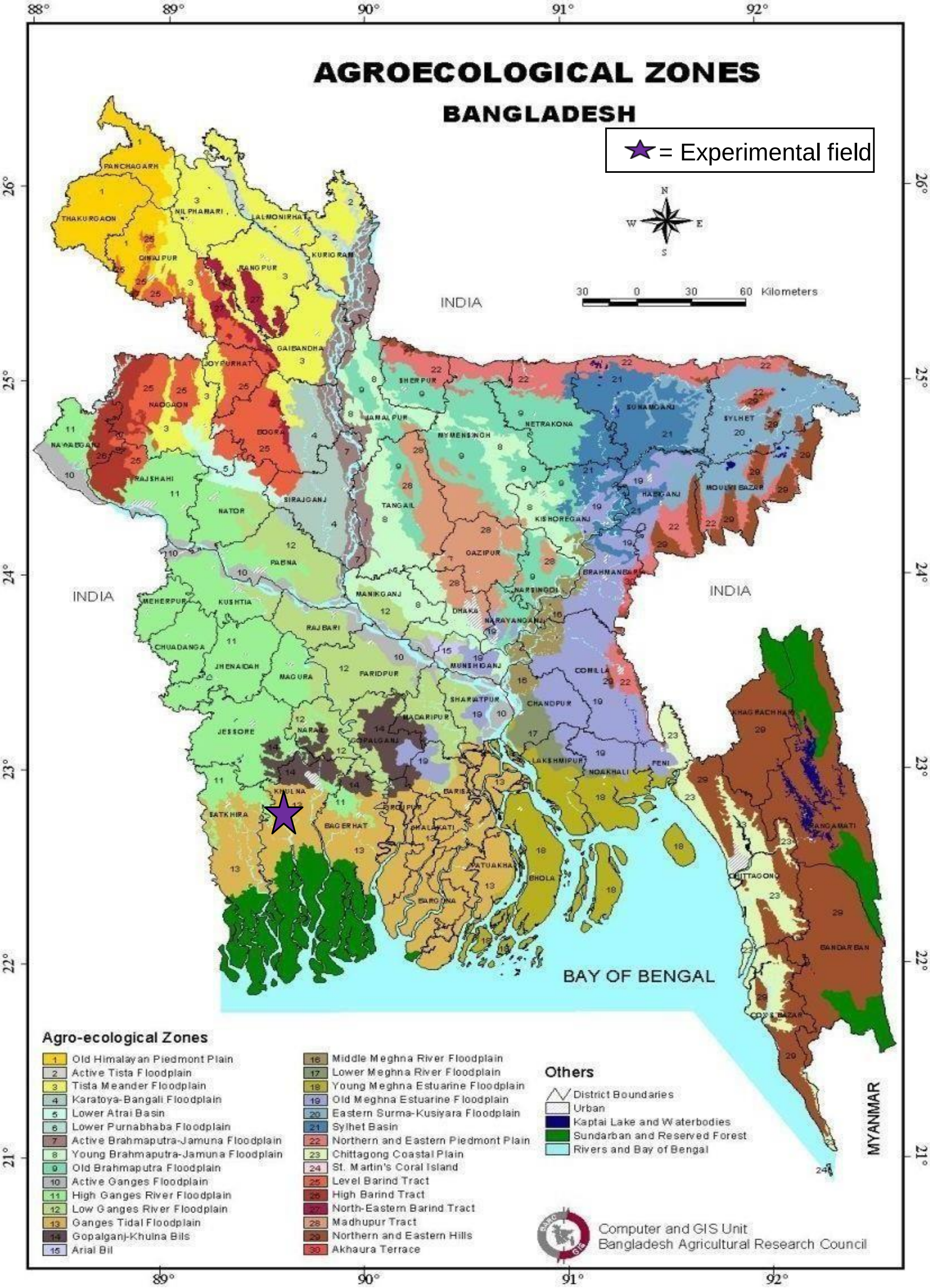
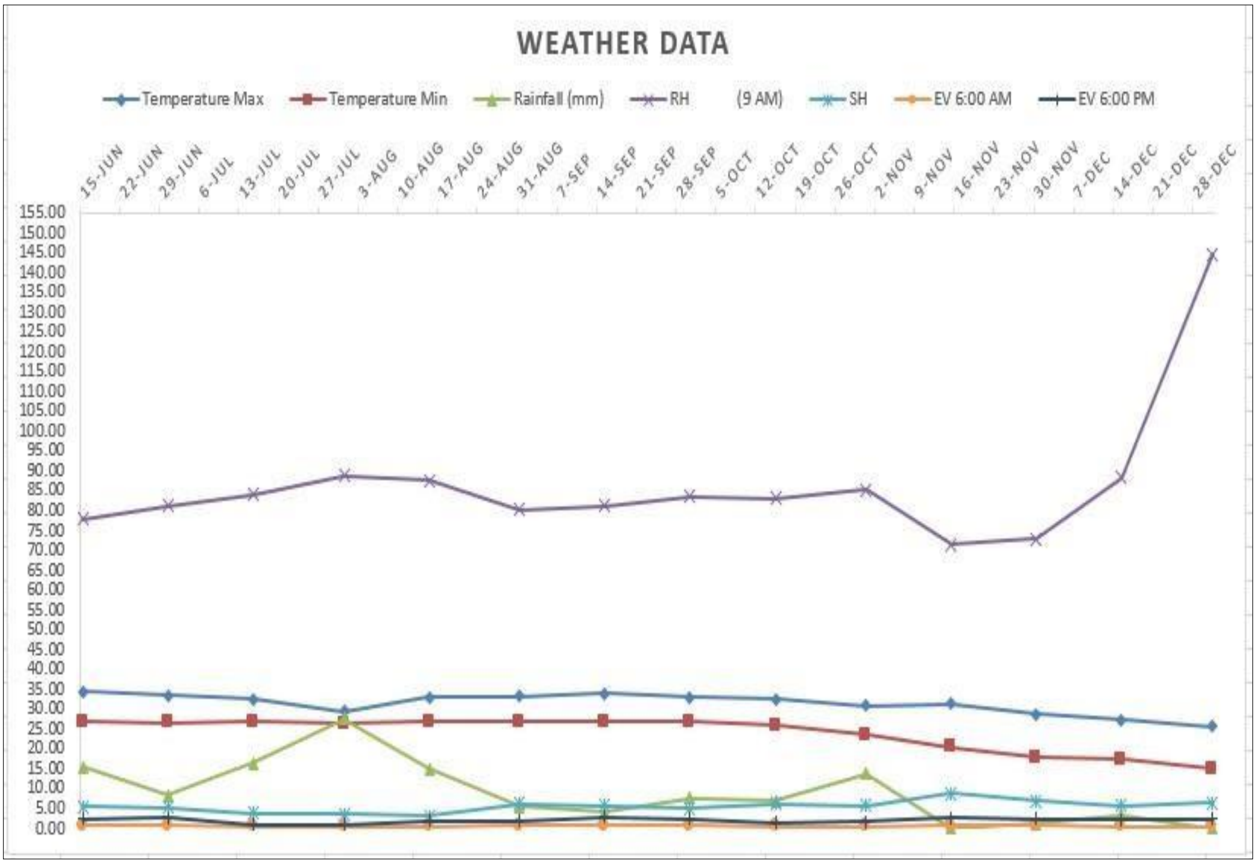
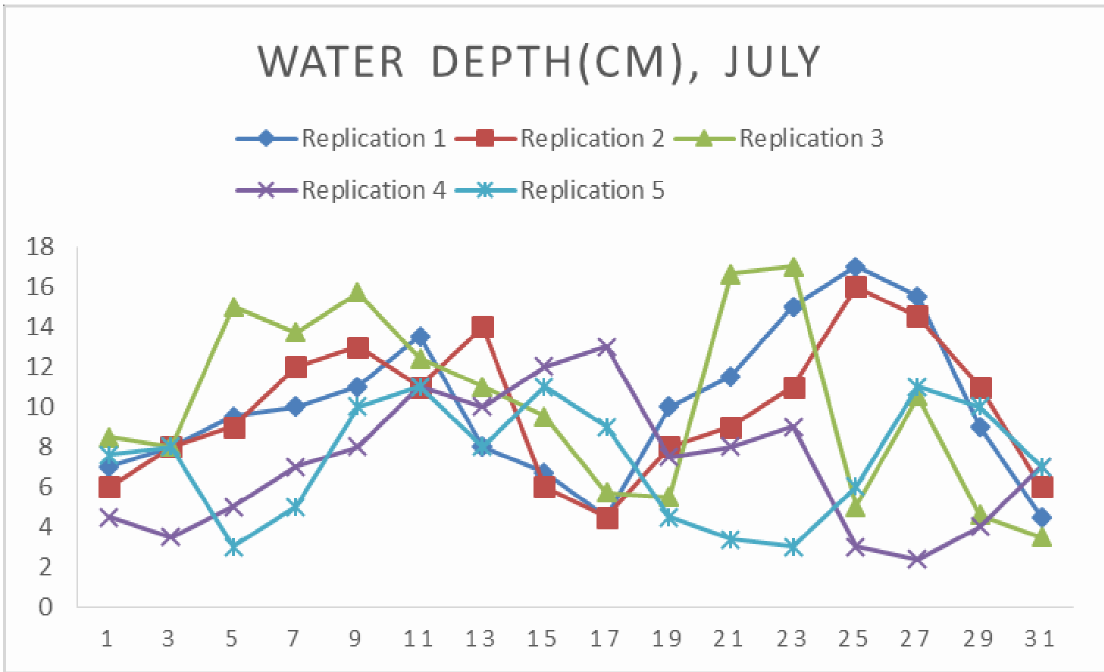
Appendix I. Experimental location on the map of Agro-ecological Zones of Banglade

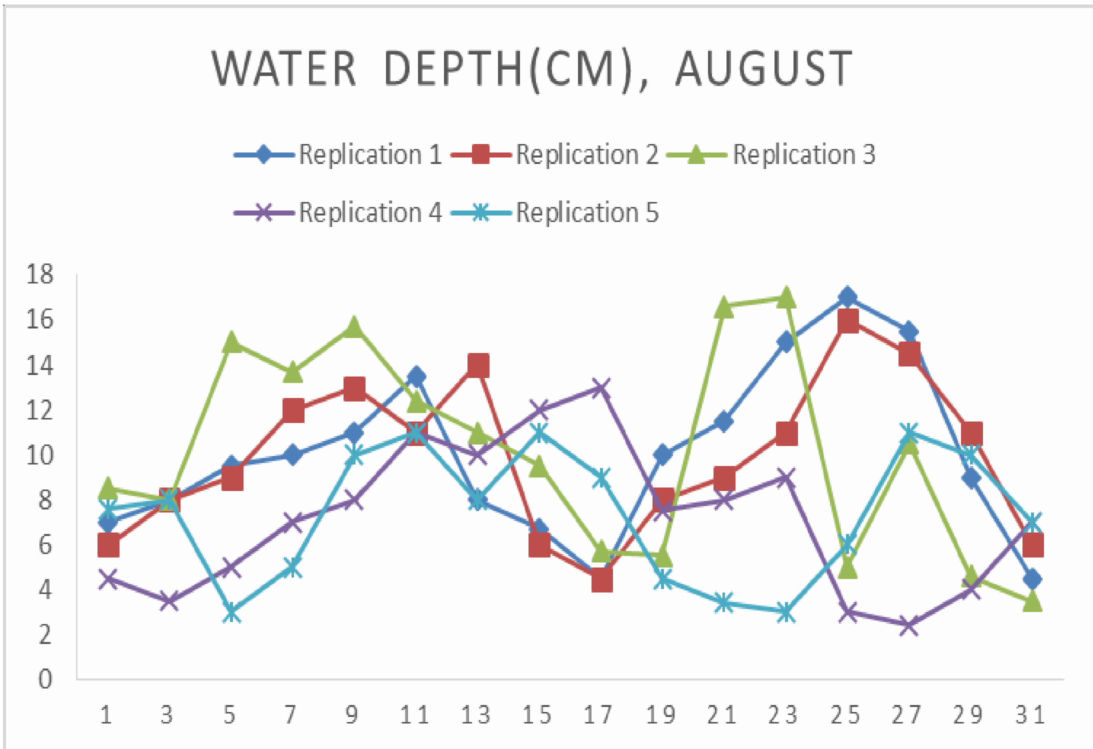


Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from June 2017 December 2006 [Source: Kulna Meteorological Station, Khulna]

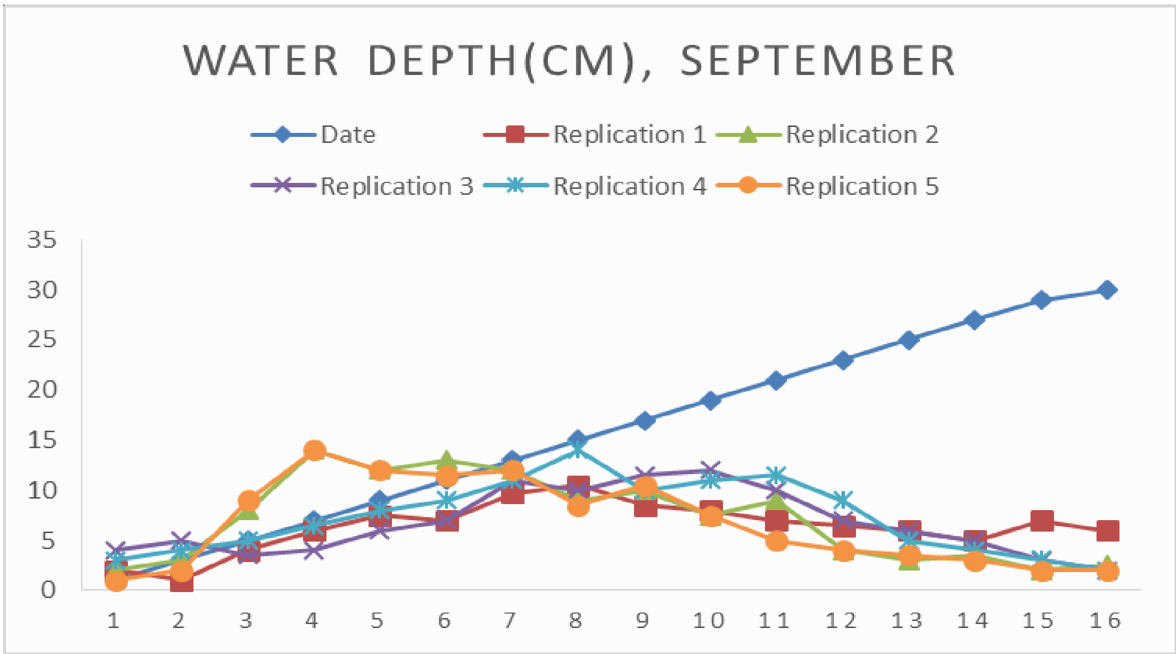


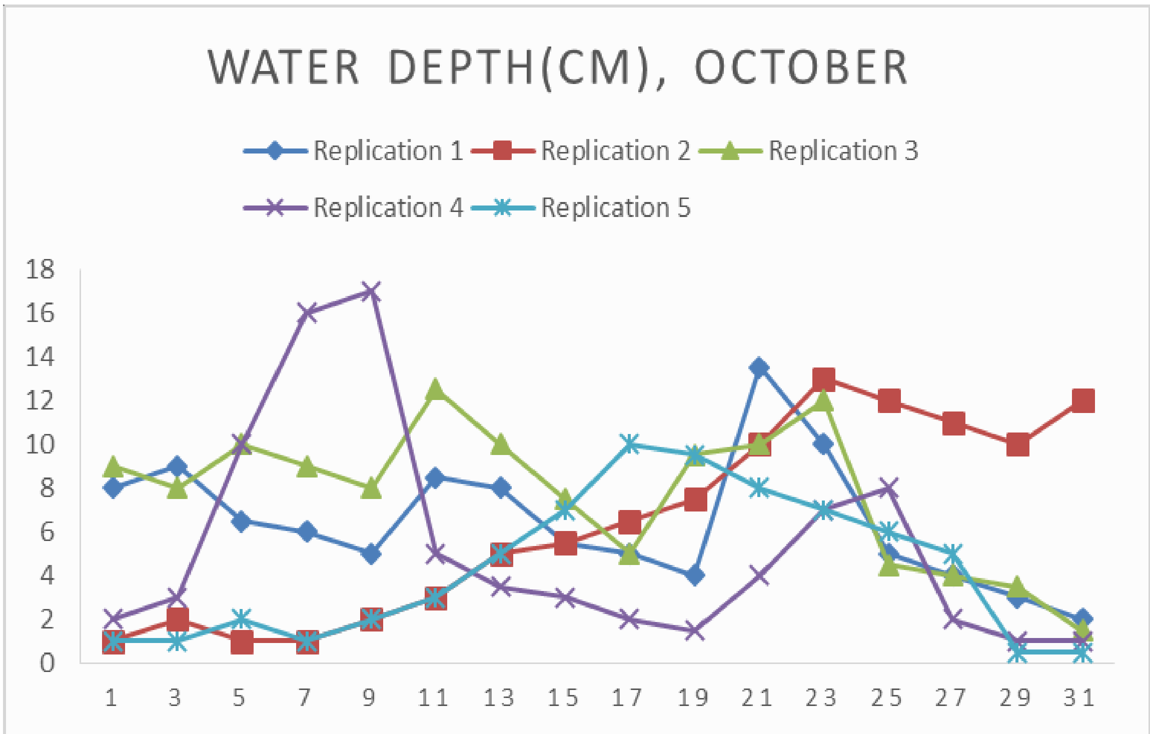
Appendix III. Daily water depth (cm) of the experimental plots





Appendix III. Daily water depth (cm) of the experimental plots





Appendix IV. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Physical composition:

Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	**Value**
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.027
Phosphorus	6.3 µg/g soil
Sulphur	8.42 µg/g soil
Magnesium	1.17meq/100 g soil
Boron	0.88 µ g/g soil
Copper	3.54 µg/g soil
Zinc	1.54 µg/g soil
Potassium	0.10 µg/g soil

Source: Soil Resources Development Institute (SRDI), Batiaghata, Khulna

Appendix V. Mean square values of the data on plant height of rice as influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of plant height at different days after transplanting (DAT)						
		30	45	60	75	90	105	At harvest
Replication	4	63.75	112.56	107.81	141.78	88.68	594.00	360.25
Variety (A)	1	19187.41*	28453.42*	29953.74*	24850.71*	20980.07*	21407.76*	18241.75*
Transplanting date (B)	6	185.06*	384.87*	825.58*	530.85*	551.69*	552.73*	476.30*
Variety (A) X Transplanting date (B)	6	70.14*	42.18*	25.15*	71.82*	156.32*	158.53*	65.48*
Error	52	32.59	46.92	81.27	64.80	104.66	65.05	100.95

*Significant at 5% level of significance

NS Non significant

pendix VI. Mean square values of the data on number of tillers hill^{-1} of rice as influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of number of tillers hill^{-1} at different days after transplanting (DAT)						
		30	45	60	75	90	105	At harvest
Replication	4	2.21	5.53	0.49	2.06	3.66	3.85	2.68
Variety (A)	1	187.09*	156.48*	233.66*	480.14*	400.80*	313.30*	53.37*
Transplanting date (B)	6	85.31*	100.98*	151.49*	247.91*	159.87*	143.64*	94.84*
Variety (A) X Transplanting date (B)	6	16.34*	11.97*	6.87*	64.01*	8.32*	9.41*	4.23*
Error	52	1.52	3.17	5.34	4.87	3.17	2.18	1.74

*Significant at 5% level of significance

NS Non significant

Appendix VII. Mean square values of the data on dry matter weight hill^{-1} of rice as influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of dry matter weight hill^{-1} at different growth stages of plant	
		At flowering stage	At maturity stage
Replication	4	12.52	92.59
Variety (A)	1	1456.92*	6152.16*
Transplanting date (B)	6	558.22*	1400.49*
Variety (A) X Transplanting date (B)	6	99.46*	36.67*
Error	52	10.33	29.59

*Significant at 5% level of significance
^{NS} Non significant

Appendix VIII. Mean square values of the data on days to flowering and maturity of rice as influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of	
		Days to flowering	Days to maturity
Replication	4	2.79	3.79
Variety (A)	1	6508.93*	6508.93*
Transplanting date (B)	6	138.10*	150.60*
Variety (A) X Transplanting date (B)	6	3.10*	5.60*
Error	52	2.17	1.75

*Significant at 5% level of significance
^{NS} Non significant

Appendix IX. Mean square values of the data on number of effective tillers and ineffective tillers hill^{-1} influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of	
		No. of effective tillers hill^{-1}	No. of ineffective tillers hill^{-1}
Replication	4	2.17	0.10
Variety (A)	1	3.43*	2.90*
Transplanting date (B)	6	70.64*	0.07*
Variety (A) X Transplanting date (B)	6	4.01*	0.11*
Error	52	0.93	0.05

*Significant at 5% level of significance
^{NS} Non significant

Appendix X. Mean square values of the data on number of fifed grains panicle^{-1}, number of unfilled grains panicle^{-1},panicle length and 1000 grain weight of rice as influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of			
		No. of fifed grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Panicle length	1000 grain weight
Replication	4	52.55	19.70	3.07	5.96
Variety (A)	1	993.55*	14020.67*	81.97*	131.66*
Transplanting date (B)	6	1000.79*	161.11*	33.19*	50.95^{NS}
Variety (A) X Transplanting date (B)	6	27.91*	2.06*	2.58*	5.54*
Error	52	47.99	15.50	5.05	5.71

*Significant at 5% level of significance
^{NS} Non significant

Appendix XI. Mean square values of the data on grain yield, straw yield, biological yield and harvest index of rice as influenced by combined effect of variety and transplanting date

Source of variation	Degree of freedom	Mean square value of			
		Grain yield	Straw yield	Biological yield	Harvest index (%)
Replication	4	0.10	0.07	0.23	10.84
Variety (A)	1	3.56*	4.39*	0.04*	1333.81*
Transplanting date (B)	6	3.35*	1.41*	8.26*	121.16*
Variety (A) X Transplanting date (B)	6	0.42*	1.73*	1.43*	222.50*
Error	52	0.08	0.09	0.18	14.29

*Significant at 5% level of significance
^{NS} Non significant

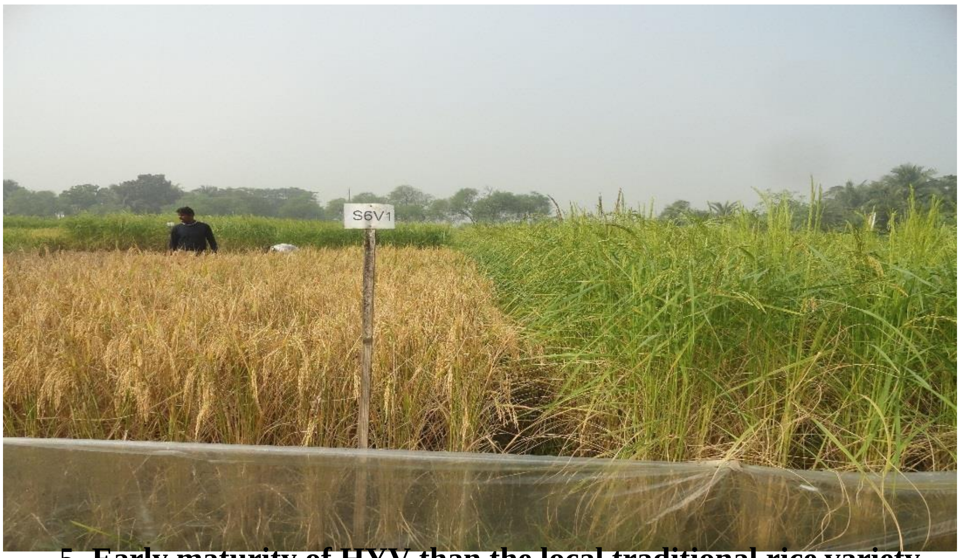
PLATES

1. **Field view of experimental field during transplanting**

2. Field view of the differences among variety at vegetative stage

3. Field view of tidal flood water phenomena in the experimental plots

4. Field view of physiological maturity stage of BRRI dhan52(HYV) and Kumragor (Local Variety)



5. Early maturity of HYV than the local traditional rice variety

6. Local safety measure to avoid rodent attack